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Record-Breaking Annual Meeting
Horizons in Analytical Chemistry
Russia Poses New Industrial Threat

American Society for Testing Materials

RESEARCH AND STANDARDS FOR MATERIALS

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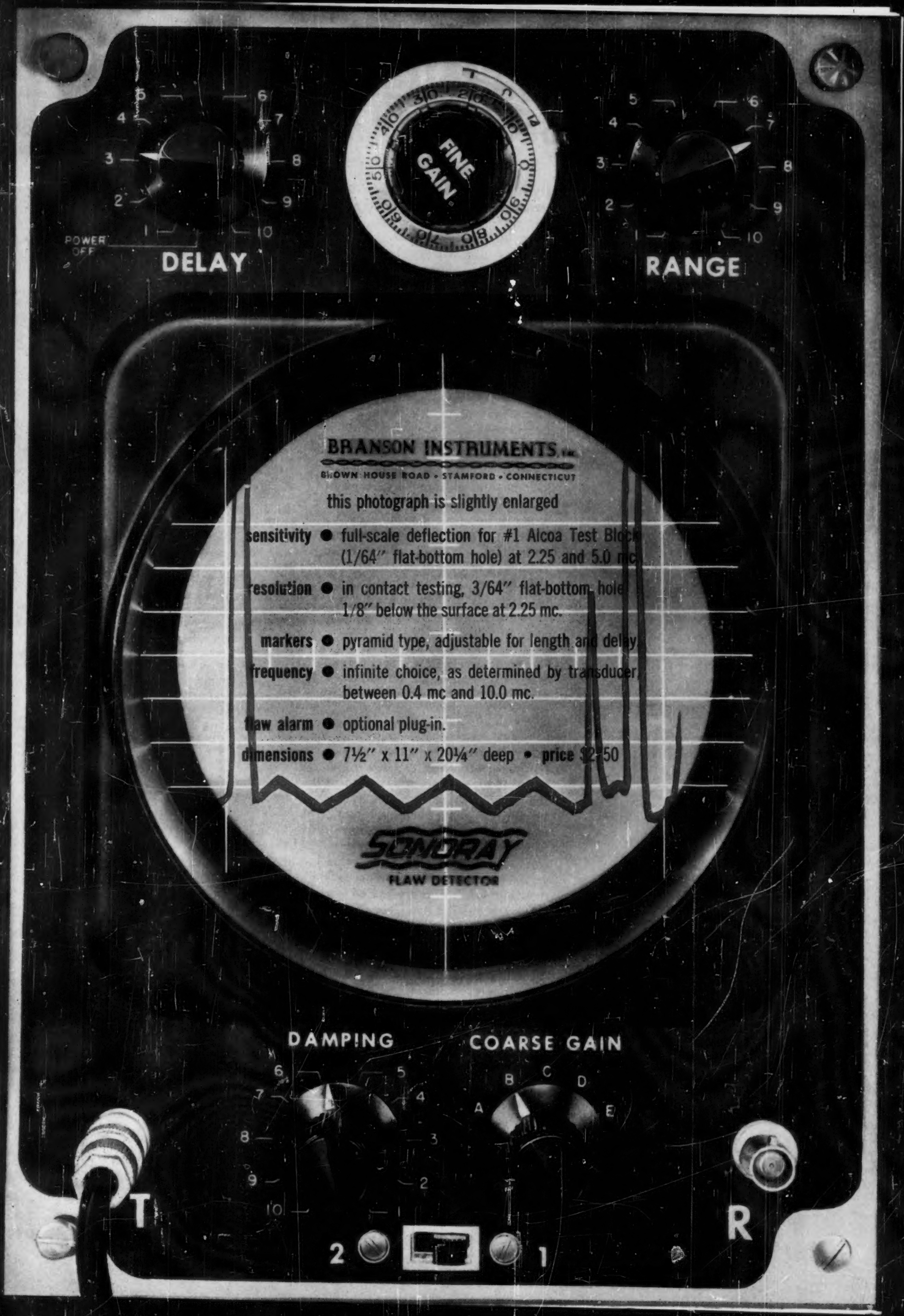
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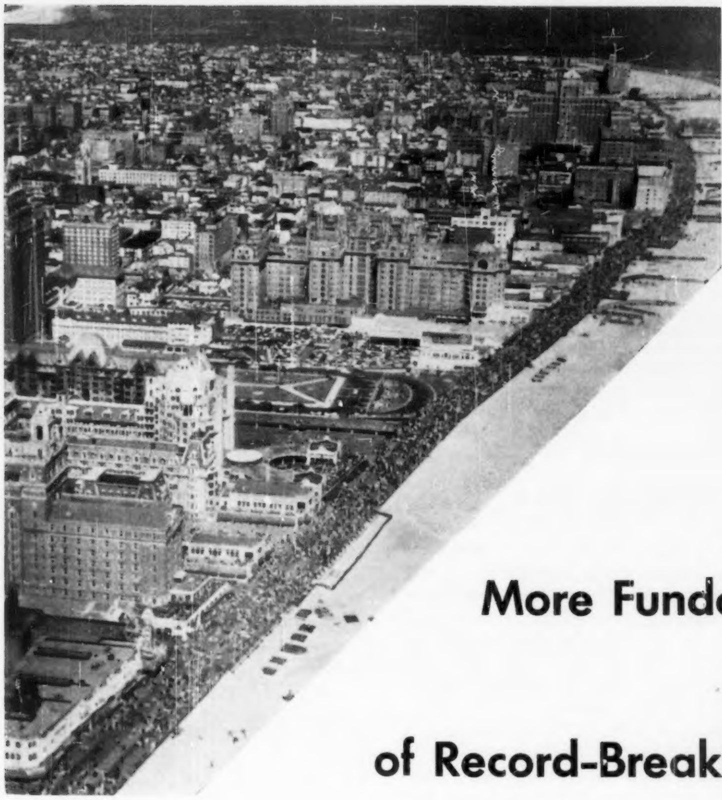

62nd Annual Meeting

More Fundamental Knowledge is Recurring Theme of Record-Breaking Annual Meeting

A PLEA for less empiricism and a more fundamental approach to materials problems ran like a thread through many of the addresses and other activities at the 62nd Annual Meeting. In a time marked by growing realization that the problems of materials are among those most vital to the advance of technology, it was perhaps a surprise to no one that attendance at the meeting reached an all-time high—registration was a record 3132. As President Woods said in his retiring-president's address, "solving the problems of materials will be the key to success in the broader problems introduced by the space age."

In his Gillett Lecture on dislocations, Dr. John C. Fisher saw this relatively new study of crystalline materials on the submicroscopic scale as a tool for future improvement of engineering properties. Dr. Herman F. Mark, in his Marburg Lecture, told of polymer chemists experimenting with new combinations of atoms and stringing together chain molecules Tinkertoy-fashion. At the Highway Industry Luncheon, Ellis Armstrong called continued research the key to a better future. "It is through basic research," said Mr. Armstrong, "that we can learn to identify materials, acquire an intimate knowledge of their nature, and ultimately find ways to take full advantage of their individual characteristics."

Organization of the Materials Science Division of the Society, called by President Woods "perhaps one of the most important additions to the scope of the Society since its inception," was furthered at the meeting of an advisory committee comprising some 25 men outstanding in their respective fields. This committee reached some tentative agreement on the scope and activity of the new Division, and planned for additional discussion at the West Coast Meeting in San Francisco in October.

At a forum on research sponsored by the Administrative Committee on Research and attended by the national officers of the Society as well as representatives of the technical committees, discussion ranged over the entire spectrum of research in ASTM. This forum had as its purpose the focusing of attention on the scope and purpose of the many kinds of research in the Society. The resulting lively discussion was of great value to the technical committee representatives as well as to the members of the Administrative Committee.

Committee Work Forges Ahead

The main business of the Society—formulation of materials standards and test methods for industry—took place in the more than 900 meetings of technical committees and subgroups who have the gigantic task of keeping up-to-date the existing standards and devising new standards which are the backbone of commerce in materials. The responsibility of these groups to industry is to see that the constant flow of new knowledge about materials is continually reflected in these standards. A list of new tentatives approved at the Annual Meeting appears on page 30. A more complete account of the committee activities will appear in the September issue of the BULLETIN.

New National Officers, Honors and Awards

Biographical information on the incoming President Frank L. LaQue and Vice-President Miles N. Clair appears on page 20. Newly-elected members of the Board of Directors are introduced on pages 21 and 22. The address of the retiring president, Kenneth B. Woods which was the feature of the President's Luncheon, appears on page 9.

A number of special awards honoring members of the Society were presented. Recipients of these awards and information about their contributions to the Society appear on following pages.

Growth and Change in Store for ASTM

Greater science-orientation in the engineering school curricula and in the engineering profession will have great impact on ASTM in the future. This was the theme of the annual President's Address delivered by retiring President K. B. Woods. President Woods noted the accelerating pace of technological development, reviewed the gradual replacement of "craft" and "skill" courses by fundamental scientific courses in the engineering schools, and predicted that these two continuing trends would have great impact on the work of ASTM in years to come. "In my opinion," said President Woods, "engineering in all its branches has undergone more fundamental changes during the past seven or eight years than has occurred during the previous 30 years or so." The retiring president concluded that ASTM must be prepared in the future to provide standards for many new materials, to expand its membership, and to provide more publication space for all segments of the Society's vast structure. The complete text of President Woods' address appears on page 9.

Basic Knowledge of Highway Materials Needed

Bituminous materials have been in use since the days of the Pharaohs—yet our knowledge of them is still mostly empirical. Thus did Ellis L. Armstrong, in his address at the Highway Materials Luncheon, illustrate the need for more fundamental knowledge of all the materials used in the construction of highways. Mr. Armstrong, U. S. Commissioner of Public Roads, stated that our three-year-old national highway program is the greatest public works program in history. Many billions of dollars will be spent on materials alone. Continued research leading to new basic knowledge of these materials could effect tremendous savings. Mr. Armstrong hoped for the day when the highway engineer could specify the properties he needs and the producer could proceed to turn out a tailor-made product to meet the need. To some extent, he stated, this is now being done in the fields of plastics and petroleum products. With a greater fundamental knowledge of highway materials, the same might be possible in that field.

Marburg Lecturer, Prof. Herman F. Mark, director, Polymer Research Inst., Polytechnic Institute of Brooklyn, receives a certificate and honorarium from ASTM President Woods. ASTM Executive Secretary Robert J. Painter stands at the right.

Marburg Lecture

Stereoregularity—Key to New Polymer Properties

One thousand Ångstrom units is a good length for a polymer molecule. With chain lengths of this order, maximum strengths will be developed in textiles, plastics, and the like. According to Prof. Herman Mark, the mechanism of separation, that is, breaking in tension of polymeric materials, involves the slipping of molecular chains along each other. Breaking of chemical bonds is generally not involved. Professor Mark indicated that a good criterion of the strength of a polymer is its degree of polymerization or molecular weight, with strength increasing with molecular weight. Other factors such as orientation are involved. Fibers and films are generally oriented by stretching, which causes packing of the molecule and increases density and tensile strength. Oriented polymers are more crystalline because the parallel molecular chains packed together form small crystallites throughout the material. High strengths can be obtained with highly oriented polymers, particularly fibers and films—up to 200,000 psi for polyethlyene and 160,000 psi for nylon. Even these high strengths are far below the theoretical strength of about 3,000,000 psi, which is not attained because of imperfections.

Stereoregularity. Tracing the work of Ziegler in Germany and Natta in Italy several years ago, Professor Mark told how their work had led to the present new era of stereoregulation in polymers. Thanks to the work of these two pioneers and others, it is now possible not only to produce polymers with high molecular weights and a high degree of orientation but also with a very high degree of orderliness and regularity in their molecular backbone. These new type, regular polymers may be isotactic—having side groups on one side of the chain, or syndiotactic—having side groups alternating in position on the chain. These new polymers also melt at higher temperatures than their less orderly cousins. The new techniques, which are just beginning to be exploited commercially, have laid the way to development of plastics, textiles, adhesives, and coatings which will have increasing resistance to deformation at high temperatures and other desirable properties.

New Polymers—New Problems. In the effort to synthesize polymers having high rigidity at elevated temperatures, polymer chemists are experimenting with new combinations of atoms, including some of the metals, such as aluminum, magnesium, and tin. One such polymer has a backbone chain consisting of alternating atoms of aluminum and oxygen, and side chains of oxygen, silicon, and hydrocarbon groups. This polymer has been cast from solution in xylene and found to melt at about 450 C. Another promising polymer from the theoretical point of view is polyphenyl—a string of benzene rings strung out end-to-end. Professor Mark indicated that while theoretically this should have good properties, no one had yet worked out a method of producing it. It is too insoluble for presently known techniques. However, a polymer ring compound can be formed from polyacrylonitrile to produce so-called "black Orlon." Professor Mark demonstrated the heat resistance of this material by holding a match to a wad of the fiber, which glowed but did not burn. He indicated however, that this was not a commercial product because of the very high rigidity of the molecular chain with consequent lack of internal mobility. As the rigidity of the chain is increased, the thermal stability is increased but other desirable properties may be lost. Also, as the chain gets more rigid, it is more difficult to orient so as to obtain high density and crystallization. Professor Mark pointed out that these are current problems in the polymer field but there are indications that many of them are on the way to being solved, thus narrowing the gap between the properties of polymers and those of metals and ceramics.

Gillett Lecture

Dislocation Theory Holds Future Promise

Those who attended the Gillett Memorial Lecture, sponsored jointly by ASTM and the Battelle Memorial Institute, were treated to a brilliant review of the theory of dislocations and its place in modern materials technology.

John C. Fisher, the lecturer, and Battelle President B. D. Thomas, who introduced Dr. Fisher, both paid tribute to Horace W. Gillett, whose memory is perpetuated in this lecture.

Dislocations, which are missing atoms causing "kinks" or "wrinkles" in the crystal lattice, have come under intensive study only within about the past decade. Dr. Fisher's description of their nature was supplemented by motion pictures of the "bubble raft," an ingenious device by which a two-dimensional array of soap bubbles can be made to portray vividly crystal structure, elastic deformation, and the swift movement of dislocations across the crystal, which is the mechanism of plastic deformation.

Two striking triumphs of dislocation theory were described by Dr. Fisher. One was the calculation of grain-boundary energy by use of the theory, which was later supported by experimental results. The second was the prediction of crystal growth in a spiral pattern around a screw dislocation. Recent motion pictures, used to illustrate the lecture, show this actually happening under the microscope.

The Gillett Lecturer, John C. Fisher (second from left), Metallurgy and Ceramics Research Department, General Electric Co., chats with ASTM President K. B. Woods (left), Dr. B. D. Thomas, president of Battelle Memorial Institute, and ASTM President-elect, F. L. LaQue before the lecture.

During plastic deformation, dislocations multiply and move across a crystal, forming the familiar slip bands. Dr. Fisher described the dislocation-theory explanation for two kinds of hardening. In precipitation hardening, the precipitated particles block the movement of dislocations by a "keying" action on the slip planes. In work hardening, the rapidly multiplying dislocations "tangle"—that is, they interfere with each other's movement.

The crying need today is for more and more high-temperature strength. In Dr. Fisher's opinion, we have gone nearly as far as we can in this direction using present-day empirical methods of alloying and treating metals. He believes, however, that a more fundamental knowledge of material behavior, as represented by the theory of dislocations, holds much promise for the future.

Symposia and Sessions — 62nd Annual Meeting

Effect of Temperature

Data on Cufenloy 30

Data on the physical and mechanical properties of Cufenloy 30, a copper-nickel alloy, indicate it has the proper combination of strength, ductility, and stress-corrosion resistance to make its use advantageous for unfired pressure vessel applications at temperatures up to about 900 F. This was the conclusion of a paper on "Properties of 70-30 Copper-Nickel Alloy at Temperatures Ranging up to 1050 F," by W. F. Simmons, D. N. Williams, and R. I. Jaffee, presented by Mr. Simmons at the session on Effect of Temperature.

Copper-nickel alloy tubes have been used successfully for many years in heat exchangers and unfired pressure vessels operating at elevated temperatures. However, design factors based on annealed material have limited the 70-30 copper-nickel alloy tubes to uses and designs that have failed to take full advantage of the higher mechanical properties obtainable with this alloy. This investigation is an attempt to fulfill this need. The alloy evaluated contained 70 per cent copper, 29.1 nickel, 0.5 iron, 0.35 manganese, and less than 0.01 lead in the drawn and stress-relieved temper.

Tensile, creep, and rupture properties were determined for temperatures up to 1050 F. Other properties studied included thermal expansion, thermal and electrical conductivity, electrical resistance, and dynamic modulus of elasticity.

The authors emphasized that this alloy meets the need for improved mechanical properties in the 70-30 copper-nickel alloy composition. They also suggested that the drawn and stress-relieved temper should be considered for inclusion in the ASTM specification for Copper and Copper-Alloy Seamless Condenser Tubes and Ferrule Stock (B 111).

Cement

Test for Workability?

At the session on cement, A. D. Conrow presented a paper on the problem of evaluating plasticity and workability of pastes and mortars. Measurements were made of the rates of deformation of hemispherical specimens when tested on the flow table. It was found that the deformation was apparently related to the energy of the drop by an equation of the type $F = AE^b$, in which F is per cent flow, E is an energy coefficient, and A and b are constants related to factors affecting workability. It was suggested that this method of test and interpretation may be found useful in a variety of investigations involving changes in properties associated with workability. Dealing as it does with problems which have been under study for a long time, the paper evoked much discussion and several comments complimenting the author on his work.

The paper "Quantitative Determination of the Four Major Phases in Portland Cements by X-Ray Analysis," by Messrs. Brunauer, Copeland, Kantro, Weise, and Schulz was presented in abstract by Hubert Woods. It described a method for the direct determination of the amounts of the four major phases (tricalcium silicate, dicalcium silicate, tricalcium aluminate, and calcium aluminoferrite) as well as the composition of the calcium aluminoferrite phase in portland cement by X-ray quantitative analysis. The authors concluded that the X-ray method gives more accurate results than do older methods and that it appears to have possibilities to replace chemical analysis and potential compound calculation in industrial practice.

A paper on the "Control of Gypsum in Portland Cement," by B. Tremper was presented in Mr. Tremper's absence by T. B. Kennedy. The paper discussed progress in devising simple, practical tests to demonstrate the relationship of the SO_3 content of portland cement to its optimum value. The test methods described were patterned on the principles set forth by Lerch in 1946, namely, that for each cement there is an optimum SO_3 content which produces maximum strength and minimum volume change and which is related to the rate of depletion of gypsum during the early stages of setting and hardening. Emphasis was placed on results of cooperative testing for short-time expansion in water and contraction in air for mortars containing the cement in question and the same cement to which pulverized gypsum is added in the laboratory to increase the SO_3 content by 0.5 percentage point.

A very interesting paper, which described a process in the manufacture of

(Continued on page 12)

Symposium on Education in Materials

Like Topsy, Curricula Have Grow'd

Probably no facet of engineering education today merits as much discussion as education in materials. Leaders in industry and education took part in a symposium sponsored jointly by the American Society for Engineering Education and ASTM at the Annual Meeting to exchange viewpoints on how to teach materials.

Introducing the symposium, ASTM President K. B. Woods observed that all fields of technology are developing at a rate unmatched in history. He viewed with concern a lack of interest in some engineering schools in encouraging the better students to pursue graduate studies and research, but on the other hand noted that many schools are expending much effort in the development of Master of Science and Ph.D. programs in engineering.

ASTM President-elect F. L. LaQue pointed out that any over-all scheme of education must be adaptable to the abilities and the interests of each student. These abilities and interests will encompass a broad spectrum from a prime interest in almost pure science at one end to a complete preoccupation with the practical aspects of engineering at the other. Engineering education itself must cover a similar spectrum. Mr. LaQue pointed out that ASTM interests, in the engineering properties of materials as defined in ASTM standards, are predominantly in the more diffuse middle ground of the spectrum.

Continuing, Mr. LaQue observed that the percentage of freshmen in engineering courses who fail to graduate is already much too large. We cannot afford to waste limited educational facilities on unqualified or poorly prepared students. He observed that there should be a reversal of the present trend toward making things easier for high school students. This dilutes the substance of high school education and, even worse, weakens mental discipline so that the college student lacks the habits of concentration and dependence on his own work that he should have cultivated in high school.

The educators' viewpoint was ably presented by William T. Alexander, Dean of Engineering, Northeastern University, and president of the American Society for Engineering Education, who stated that all thoughtful engineering educators agree on the need to progress toward a more theoretically oriented engineering curriculum. They disagree, he believes, in only two respects: how fast and how far? He urged that as educators strive to make the necessary transitions they should not forget two very important points: "(1) The engineers whom we have been, and are, graduating are not failures. They have been and are contributing relatively well to our progress, and certainly the techniques which they now use are very different from those which they studied in college. We are obviously dealing with a group of people who are very adaptable. Furthermore, we cannot hope to teach them what they will need to know over the next 25 years. This leads to the second point: (2) The way we teach the subject matter in our respective colleges, whatever its intrinsic nature may be, will have more to do with the eventual success of our graduates than the particular subjects which they study or possibly to what degree they are theoretically oriented.

In presenting industry's viewpoint, Melvin F. Wood, chief engineer, E. I. du Pont de Nemours & Co., Inc., pointed out that the proper selection of materials and control of their quality is crucial to industrial success; the manufacturer must know his materials to make sure his customers get what they pay for; the purchasing agents need the materials engineer to help them get value for their materials dollar.

Mr. Wood observed that the large industrial organization and the teams of experts it supports assign extraordinary importance to the qualities of leadership and effective human relations. Thus it seems reasonable that in the future formal education should put considerable emphasis on the development of these qualities.

Glenn B. Warren, president of The American Society of Mechanical Engineers and vice-president, Turbine Division, General Electric Co., described four phases of demands the design engineer must make on the materials engineer: "(1) He needs materials to increase the reliability or life of existing machine designs. (2) He needs materials to permit an increase in the power, efficiency, range of application, etc., of existing machine designs. (3) He needs materials and fabrication processes that will permit reduced costs or lower-cost designs to be made. (4) He needs new materials and concepts, and promises of these, to permit innovations, the building of new machines, devices, and processes never dreamed of before."

Dr. Eric A. Walker, president, The Pennsylvania State University, in his talk at the Education Luncheon, observed that one of the problems facing the engineer educator today is the fact that we have never *designed* a program for engineering education. Like Topsy, our engineering curricula just "grow'd." Remarking about the difficulties in teaching communication skills to engineers, Dr. Walker expressed the belief that engineers will not become experts in communication skills until the teachers insist that the student communicate effectively in all his courses.

This Symposium on Education in Materials will be published by ASTM as a Special Technical Publication.

In the afternoon session, Dr. Glenn Murphy, Head of the Department of Theoretical and Applied Mechanics, Iowa State College, and Vice-President, ASEE, speaking on the nature and properties of materials, presented a follow-up of the ASEE report on evaluation of engineering education. In the materials field, he said, it is more important to teach the science of materials than it is the art.

Jacob E. Goldman, manager, Physics Department, Ford Motor Co., speaking on solid state phsyics in relation to materials science, education, and industry, emphasized the great strides made in recent decades in the materials sciences and the compression of the time scale between scientific discoveries and the practical application of these discoveries. According to Dr. Goldman, we must junk the "black box idea" where the scientist decides what should go in and what should come out and then leaves it up to the engineer to work out the details. The engineer must know more of the whole problem. We should make our engineers engineering scientists.

Prof. Henry A. Lepper, Jr., Department of Civil Engineering, University of Maryland, presented the viewpoint of the civil engineering educator. While laboratory work should be continued to give the engineering student an understanding of how materials react to testing, the long hours devoted to actual manipulation and measurement can well be used in other phases of the engineer's education.

Maurice E. Shank, associate professor, mechanical engineering, Massachusetts Institute of Technology, summarized the degree in materials engineering and related topics being initiated at M.I.T. The graduate program in materials engineering may be aimed toward the degree "Materials Engineer" following two years of work, including a thesis and a qualifying examination, or a doctorate in materials.

The President's Address

62nd Annual Meeting

This address, delivered by outgoing President K. B. Woods at the President's Luncheon, Tuesday, June 23, points up the stress being given to fundamentals in engineering school curricula and emphasizes that this fact, which is a symptom of a fast-growing technology, implies continuing growth for ASTM and increasing demands for its services to that technology.

The Impact of Science on ASTM

By K. B. Woods

Passing the gavel as a symbol of the President's responsibilities. President K. B. Woods at left, President-elect Frank L. LaQue at right. At the conclusion of the meeting Mr. LaQue, on behalf of the Society, presented President Woods with a gavel as a gift from the Society.

IT IS A BIT trite to state that "new developments in science are of great importance to the work of ASTM." However, this statement becomes quite realistic by making a simple comparison of the status of engineering and scientific developments at the time of the beginning of ASTM with the present status almost 60 years later. In 1900, the telephone was a feeble device—the use of electricity had hardly begun—automobiles were 2-cylinder buggies—there were no road systems. We still had malaria, typhoid fever, and a multitude of other diseases rarely encountered today.

In contrast, in communications we now have superb telephone systems, radio, and both black-and-white and color television. We have automobiles—almost two cars to the family—and airplanes and automobiles are fast replacing trains as a common method of transporting people. Radar is used for many purposes—the latest to measure with high precision the distance to the planet Venus; we have rockets, guided missiles, and there seems to be little doubt about man conquering at least a portion of outer space in the immediate future.

During this same period, parallel development took place in engineering education. In 1900 we had no schools of aeronautical, industrial, chemical, or metallurgical engineering, and the curricula of civil, mechanical, and electrical engineering were packed with laboratory courses and subject matter now considered in the "skills" category. In 60 years, this concept has been replaced by a scientific-professional one with more and more emphasis on the fundamentals.

The history of ASTM also follows this pattern. At the turn of the century, the research data, standards, specifications, and methods of tests were quite simple—at least when compared with the 14,000-page book of standards released this year.

It is my purpose today to expand on this theme: to examine the expanding role and heightening status of science, engineering curricula, and the ASTM during the last half century. Finally, I shall venture to project the work of ASTM a modest distance into the future and will offer some suggestions for future administrative procedures.

Engineering Education

An inspection of a 50- or 60-year-old bulletin of any good school of engineering will show, in comparison with 1959 offerings, amazing changes. In one such instance, a 1910 bulletin contains a listing of over 40 semester hours of required material in shop, railroad curves, surveying, and related material required for the B.S.C.E. degree. The 1959 catalog for this same institution contains no requirement for shop, three hours of good-quality mathematical engineering graphics, and six hours of high-quality surveying (in part engineering measurements), much of which is of a theoretical nature. It is probable that these many hours of shop, drawing, surveying, etc., were not especially out of line with the professional needs of the young graduate civil engineer 50 years or more ago.

Referring again to the amount of time spent on shop, surveying, and railroad curves through the years, a check on the semester hours of an important civil engineering school shows the following: 1910, 42 hours; 1920, 26 hours; 1930, 21 hours; 1940, 17 hours; 1950, 17 hours; and in 1959, 9 hours. Note the 20-year lag from 1930 to 1950. The great depression in the 1930's appears to have had an influence on the development of engineering curricula because of an apparent slowing down of the process of adding mathematics, physics, and chemistry as replacement material for some of the less important laboratory and field courses.

World War II also played a part in this evolution of engineering curricula, although of a somewhat different character. All segments of the military establishment set up programs in the colleges and universities of the country to provide for general curricula in the engineering professions, as well as specialized programs designed to accommodate students with particular abilities—in electronics, for instance. With World War II also came great advances in the physical sciences, and these in turn provided better tools for many of the great developments during this period and, later, in aeronautical, electrical, chemical, and to some extent in mechanical and metallurgical engineering. The student bodies in engineering during World War II came largely from the military establishment, and there was a rapid turnover. Immediately following the war, the engineering schools were literally swamped with unprecedented numbers of students returning from military service. Thus, it can be seen, largely because of preoccupation of our engineering faculties, both during World War II and for a few years following, that changes in engineering curricula were not as rapid as were the new developments in science. This has been true especially in civil engineering.

In the 1950's, most of us concerned with engineering education have seen

tremendous changes in engineering-curricula concepts. Not only have we been trying to catch up with some of the changes we should have made in the 1930's, 1940's, and early 1950's, but at the same time we have been making great efforts to keep pace with current developments. In my opinion engineering in all of its branches has undergone more fundamental changes during the past seven or eight years than had occurred during the previous 30 years or so.

The changes are of two general kinds: the adoption of science-oriented engineering programs, and the development of strong professional or design programs. In both cases, modern concepts of science and of engineering are gradually replacing those courses (and especially laboratory courses) that were originally designed to develop proficiency in skills.

During the current period of great change, it is difficult to project the course of engineering education very far into the future. Certain trends are noteworthy. For instance, the chemical engineer will unquestionably maintain his identity in the years ahead even though substantial changes are taking place in many of his undergraduate and graduate programs.

Again, the curricula in aeronautical and electrical engineering, engineering science, and, in many instances, metallurgical engineering, are generally significantly science-oriented. I stated earlier this week[1] that the future individual engineering identity of the undergraduate programs in these areas is in doubt. In mechanical engineering, similar trends are apparent but not in the same direction or in comparable amounts as in the highly science-oriented programs. In civil engineering, the impact of science has been as significant as in other engineering curricula; however, the civil engineering educators (and perhaps the profession itself) have not responded as quickly as in the other areas. Here, too, however, can be observed very significant changes in many institutions in which both science-oriented as well as high-level professional programs are replacing rather rapidly the programs based on old concepts. I have said on another occasion that "Civil engineering is on the threshold of serving mankind in a manner undreamed of a few years ago. The future is bright, but specialization calls for intensive graduate instruction if we are to have continued progress."[2] I think now that this statement holds for all of engineering. In this same line of reasoning, I said earlier this week "that one of the great deficiencies in American engineering education lies in our inability to attract and stimulate interest in a higher percentage of our good engineering students to pursue work toward an advanced engineering or science degree."

[1] Introduction to Joint ASEE-ASTM Symposium on "Impact of Developments in Materials Sciences on Engineering Education."

[2] *Engineering News-Record*, July 3, 1958.

Impact of Science on ASTM

In the work of ASTM it is appropriate to make comparisons of progress at different intervals and to attempt a prediction of future activity by a projection of the past and present trends. A study of membership growth and the number of ASTM standards published should be revealing.

Membership Trends

A check of the 50-year membership data of ASTM shows a rather steady climb from 800 members in 1909 to 4000 in 1930. The influence of the depression on membership is as significant as is the slow progress in modernizing engineering curricula. The membership total of 4000 in 1930 barely reached 4200 ten years later. The influence of scientific developments during World War II is again apparent with the membership climbing to about 5000 by 1945. From this period to the present, the membership has again increased sharply until we now have about 10,000 members. I think this latest surge of interest is directly related to the sharp increase in the number of major contributions from science from which has resulted not only an improvement in our understanding of basic phenomena but also the development of methods for evaluating the quality of materials. No less important is the great upsurge in the design and production of completely new engineering materials. If one is to assume that there will be a steady and perhaps even an accelerated development in pure sciences, then it appears obvious that there will also be a similar increase in our knowledge of materials and in our ability to design and produce large numbers of entirely new materials.

It follows logically enough, then, that increases in membership in the Society will continue.

Number of ASTM Standards Published

Again using the 50-year period as a base, it is interesting to note how closely the curve for the number of standards published per year follows the membership curve. For instance, there was a steady increase in the number of standards produced from about 200 in 1919 to a little over 500 in 1929. The influence of the depression also appears here, since the number published by 1939 had reached only something less than 800. The developments in scientific endeavors during and following World War II show during this 20-year period a 300 per cent increase from 800 to almost 2500 standards published. In other words, we have published three times as many standards in the last 20 years as we did during the first 40 years of the life of ASTM.

Here again, one must conclude that the value of the work of the Society will increase in the immediate years ahead and that this rate of increase will be sharply upward. However, in projecting the work of a society such as ASTM, it must be remembered that the history of all professional societies is relatively brief—in fact, it is limited largely to the life of modern technology. Consequently, our experience background is small and prognostications are difficult.

Development of Materials Sciences

Of equal importance in estimating the future trends of the Society is a study of improvements in our ability to evaluate existing materials; for instance, it would be appropriate this year to base some of our estimates on a study of highway materials since we are in the midst of the nation's great hundred-billion dollar highway program.

In considering all of these broad aspects of highway engineering and indeed of civil engineering itself, none is of greater importance than materials. Included in the highway materials field are bituminous materials, bituminous concrete, cement, portland-cement concrete, aggregates, steel, paint, plastics, chemicals, and soils.

To use soil mechanics as an illustration of the rapid change in our ability to use materials economically in the highway area, it can be seen that within a period of 25 years we have been able to develop methods of evaluation and design, and to control construction from zero level to one of serious scientific importance. As a matter of fact, the use (or nonuse) of the developments that have taken place in the soil materials and related fields in the past 25 years will probably determine to a considerable degree whether success or considerable failures shall be the lot of the currently constructed interstate highway system.

This is only one of many examples of scientific developments on highway materials in other engineering developments. In the field of cement and concrete technology Grinter[3] states, "The art of concrete construction has changed with scientific understanding of the

Head Table Guests at Highway Materials Luncheon

ASTM officers and guests placed at the head table at the Highway Materials Luncheon June 24. Standing (left to right): W. M. Creamer, chief, staff services, Connecticut State Highway Dept.; O. H. Fritzsche, New Jersey State Highway Engineer; B. D. Thomas, president, Battelle Memorial Institute; K. B. Woods, ASTM President, head, School of Civil Engineering and director, Joint Highway Research Project, Purdue University; Ellis L. Armstrong, Commissioner, U. S. Bureau of Public Roads, luncheon speaker; H. E. Davis, head, School of Civil Engineering, University of California, toastmaster; F. L. LaQue, vice-president and manager, Development and Research Division, The International Nickel Co., Inc., President-elect of ASTM; N. E. Argraves, Connecticut State Highway Commissioner; W. H. Price, head, Engineering Laboratories, U. S. Bureau of Reclamation, chairman of Committee C-9 on Concrete and Concrete Aggregates; George Verbeck, manager of the Applied Research Section of the Portland Cement Assn., winner of the Sanford E. Thompson Award; C. D. Jensen, director of research and testing, Pennsylvania State Highway Dept.; W. S. Housel, professor of civil engineering, University of Michigan, and research consultant, Michigan State Highway Dept., first vice-chairman of Committee D-18 on Soils for Engineering Purposes; W. E. Schmid, associate professor of civil engineering, Princeton University, winner of the C. A. Hogentogler Award.

Seated (left to right): R. J. Painter, Executive Secretary, ASTM; Bryant Mather, engineer, Concrete Division, Waterways Experiment Station, secretary of Committee C-9 on Concrete and Concrete Aggregates; H. L. Fry, foreman of special tests, Bethlehem Steel Co., Inc., secretary of Committee A-1 on Steel; A. B. Cornthwaite, engineer of materials and tests, Virginia Department of Highways, chairman of Committee D-4 on Road and Paving Materials and newly elected national director of ASTM; R. R. Litehiser, engineer of tests, Ohio State Highway Testing Laboratory, chairman of Committee C-1 on Cement, and a national director of ASTM; M. N. Clair, president, The Thompson & Lichtner Co., Inc., Vice-President-elect of ASTM; A. A. Bates, vice-president of research and development, Portland Cement Assn., senior Vice-President of ASTM; J. J. Kanter, directing engineer, Engineering Laboratories, Crane Co., chairman of Committee A-1 on Steel; W. J. McCoy, director of research, Lehigh Portland Cement Co., secretary, Committee C-1 on Cement; W. G. Holtz, head, Earth Materials Laboratory, U. S. Bureau of Reclamation, secretary of Committee D-18 on Soils for Engineering Purposes; D. D. Woodson, The Asphalt Inst. (representing J. M. Griffith, secretary, Committee D-4 on Road and Paving Materials).

setting process, with change in winter protection procedures, with air entrainment, with water removal techniques, with vibrations, with reusable forms, with precast elements, with lift slabs, with prestress, with fast-moving rubber tired vehicles, etc." To this list could well be added the great advances that have been made in our ability to understand and measure the physical and chemical properties of mineral aggregates, to appraise the factors which influence the durability of concrete, and of the contributions made in the past 15 years on the subject of alkali-aggregate reaction.

By the same token, our knowledge of physical and chemical properties of bituminous materials has been greatly expanded, and we have a better understanding of mix design and of the interrelationships between bitumens and aggregates.

Here again, it is appropriate to observe the impact of science—especially the developments in chemistry and physics—upon highway materials and indeed upon all of the ASTM spectrum of engineering materials. It follows, therefore, that with increased emphasis on the basic sciences in the engineering and science curricula this already heavy impact will increase in the immediate years ahead.

Design of New Materials

A vivid example of the many future developments of materials and knowledge to be sought concerning present materials can be seen in the statement of problems involved with the flight of a relatively slow-speed B-58 bomber. I have been told[4] that even in this bomber, which has a top Mach number of approximately 3, the material properties requirements due to the temperatures imposed are extremely severe. For example, in a typical B-58 mission in which the aircraft takes off at sea-level, obtains Mach number 3 velocity at 30,000 ft elevation, and drops down rapidly in Mach number at a lower altitude, certain portions of the aircraft's structure may reach temperatures as high as 1000 F. One would need to extrapolate beyond this range to determine the more severe conditions presented in missile flights. Such conditions give rise to a variety of structural and material problems. Included among these are: (1) thermal stresses due to nonuniform temperature distribution, such stresses being both static and dynamic in character, (2) changes in material properties due to the high-temperature range, and (3) creep and thermal fatigue.

It is thus seen that while we have made much progress in material technology the future holds even more challenges for us. In general, success in solving the problems of materials will be the key to success in the broader problems introduced by the space age.

Discussion and Conclusions

In this presentation, it has been observed that the impact of scientific knowledge has already produced important changes in the materials work of ASTM. The officers and the Board of Directors of the Society have recognized the importance and potentialities

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of this change to its members. The Board has provided the machinery for a new Materials Science Division which is to provide a forum and a medium for publication of basic knowledge in the field of materials. This move is, perhaps, one of the most important additions to the scope of the Society since its inception.

Summing up the information available covering the probable trends for the Society of the future, it would seem appropriate to emphasize that:

1. The *impact* of scientific developments has been of major importance and this has been especially apparent in the work of the Society in the past 15 years.
2. The *impact* of new developments is likely to be of much greater significance in the future than in the past.
3. The *response* of engineering education to the trend in accelerated developments through science will be of significance to the work of ASTM, especially in the design of new materials.

On the basis of these considerations it is my opinion that the officers, the Board of Directors, and members should continue their efforts to prepare the Society to adjust to greater demands resulting from new developments. The Society must accommodate an ever increasing membership, provide for more standards for both old and new materials, and arrange for an increasing demand for publication space from all segments of the Society's vast structure, including material from the new Division of Materials Sciences.

[3] L. E. Grinter, "Importance of Emphasis in Civil Engineering Education," *Journal of Professional Practice, Proceedings*, Am. Soc. Civil Engineers, Vol. 84, Dec., 1958.

[4] H. M. DeGroff, "Research in Aeronautical Engineering at Purdue University," address, May 1959.

Symposia and Sessions

(Continued from page 7)

portland cement of importance to the industry in alleviating "pack set" was presented by B. E. Kester. The paper, "Acetate Processed Portland Cement," disclosed that acetic acid has the unique property of creating free-flowing dry cement and does not in any measurable manner alter the properties of cement. The paper developed considerable discussion which emphasized its importance.

Concrete

Fly Ash Properties Given

The use of fly ash in concrete has become widespread. This heterogeneous material, coming from many sources and conditions of burning, varies in its composition. L. J. Minnick described the basic properties and characteristics of this material. His study included chemical and physical tests based on X-ray diffraction and fluorescent spectographic analyses, microscopic examination, and differential thermal analyses (DTA). Some doubt was expressed as to the reliability of some of the chemical analyses. The petrographic microscope was found to be not too helpful in detecting the presence of crystalline fractions. The DTA results, when correlated with strength or X-ray data, may prove to be a useful tool for initial evaluations.

Pore characteristics of coarse aggregates and their influence on the freezing-and-thawing durability of concrete is one of the newer fields of research that is receiving increasing attention. W. L. Dolch reviewed a study of simple fluid-flow measurements in an attempt to learn more about these characteristics. Density, porosity, absorption, degree of saturation, specific surface area, capillary absorptivity, permeability, and tortuosity factor determinations were made on four Indiana limestones with both good and poor field and laboratory durabilities. The author concluded that, based on the materials studied and the tests performed, the rate of increase of the degree of saturation of a material when exposed to free water and the ratio of the absorptivity to the permeability are two useful indexes of frost susceptibility when the material is used as a coarse aggregate.

Excessive expansion of concrete due to alkali-aggregate reaction was the topic of a paper by Leonard Pepper and Bryant Mather. Mr. Mather, in his presentation, reviewed 20 materials representing eight different classes of mineral admixtures using both chemical and mortar-bar test methods. The authors found that all of the materials tested in their study effectively reduce expansion if enough is used in the mixture. They found that neither chemical test, reactivity with sodium hydroxide or a modified method of this test, can be used with reliance. The mortar-bar test needs improvement to increase its precision. It was concluded that the present procedures in the Corps of Engineers Standards CRD-C 262 and 263 are satisfactory means of establishing the ability of a material to prevent excessive expansion due to alkali-aggregate reaction.

Harold S. Davis, in his paper "Concrete for Shielding Nuclear Radiations," showed that concrete can be used at normal or at high temperatures for shielding nuclear radiations if structural requirements at high temperatures can be satisfied and if allowance is made for changes in shielding properties caused by loss of water.

The use of the Proctor penetration resistance test as a measure of low-density concrete strength was described by Irwin A. Benjamin and G. D. Ratliff, Jr., in a paper entitled "An In-Place Strength Test for Low Density Concrete." The authors reported that the penetration strength is directly proportional to compressive strength under a wide range of conditions; that there is no significant difference in results obtained from different operators; and that the test is suitable for in-place strength measurement in the field or the laboratory. The concretes to which the test is applicable have oven-dried densities of less than 40 lb per cu ft.

In a paper entitled "Stresses in Deep Beams Subjected to Central and Third Point Loading," M. E. Raville and F. J. McCormick showed that for beams with a depth-span ratio of one-third, center and third point loading systems cannot be interchanged if a direct comparison of modulus of rupture values is to be made. The solution, based on theory of elasticity, predicts modulus of rupture values $11\frac{1}{2}$ per cent higher for central loading than for third-point loading. However, this figure should not be used to convert from one system of loading to the other without experimental verification.

Prof. Clyde E. Kesler reported on the results of an extensive ASTM cooperative investigation on the effect of length-to-diameter ratio on compressive strength of concrete test specimens. The study clearly shows that correction factors are independent of strength and that lightweight concretes require different factors than do normal-weight concretes.

Road and Paving Materials

Papers on Viscosity and Density Elicit Lively Discussion

Viscosity and density of asphalt and asphalt mixtures were the topics of two interesting papers presented in the Session on Road and Paving Materials. Since viscosity is of primary importance to quality control in asphalt manufacture, it is necessary to establish dependable limits of consistency and workability in both manufacture and use. The use of capillary viscometers and fundamental viscosity units as a substitute for a Saybolt Furol viscometer was described in a paper by D. F. Levy, F. E. Fassnacht, G. P. Hibler, R. D. Umbach, and D. W. Gagle, presented by Mr. Levy. In a very concise and well-organized manner, Mr. Levy reviewed the nearly three year's experience in three plants in the use of a capillary cross-arm viscometer for kinematic viscosity. On the basis of this study, it was recommended that present cut-back asphalt specifications be expanded to include alternative kinematic viscosity values at 140 F in addition to Saybolt or Furol values. The advantage of the kinematic method appears to be in connection with volatile or rapid-cure cut-back asphalts. It was shown that the test for viscosity by the kinematic method is much less time consuming, a greater number of samples can be tested simultaneously, a smaller sample size is used, and accuracy can be maintained between −100 and 700 F.

This paper elicited considerable discussion; three written discussions were presented. W. T. Halstead confirmed the reliability and applicability of the test procedure and conversion factors. L. F. Erickson supported the use of a single temperature of 140 F for all grades of liquid asphalts, and possibly asphalt cements. The use of the Shell slide plate microviscometer in conjunction with the Zeitfuchs tubes was recommended in order to give the paving engineer a better understanding of the material with which he is working. John H. Barton also gave credit to the use of the Zeitfuchs viscometer tubes at a single temperature of 140 F for all grades of bituminous materials. The speed in running this test was stressed.

A loss in density with time was observed on a large number of cores

taken from experimental asphalt-concrete pavement sections made in accordance with a Corps of Engineers' design. This led to a study of these changes in the paper by T. C. Hein and R. J. Schmidt. Data from tests on a number of cores reported by two laboratories indicated a drop in relative density approaching 2 per cent in eight days. The same tendency was found later on a large number of cores tested over an extended period. Interesting features reported by the authors included the fact that changes in density may be in contrary directions as time goes by, depending on the aggregate type and mix gradation. The authors emphasized that a number of precautions must be taken in removing and storing cores in order to secure reliable results. The inaccuracy otherwise engendered has resulted in unnecessary rerolling of the pavement as well as in the acceptance of inferior pavements. As an interim guide, a maximum time limit for testing of 4 hr after coring will preclude gross differences in results. Both of these papers were of considerable interest to those in attendance, the evidence being a considerable amount of recorded discussion from the floor.

Bituminous Binders

What Do Tests Mean?

With the great national expansion in highway and airfield construction, the amount of testing and research has increased accordingly. ASTM Committee D-4 on Road and Paving Materials, conscious of the increasing role of statistics in the testing and research of bituminous materials, sponsored an Annual Meeting Symposium on this subject.

The opening paper in the Symposium, prepared by Gene Abson, was in the nature of an historical résumé of the evolution of ASTM tests and specifications for asphaltic materials. This paper provided a very interesting review of the development of standards dating back to 1898 and closely paralleling the history of ASTM itself. Mr. Abson, in his own inimitable style, recounted the early activities in ASTM, in which he participated, dating back to 1919.

A very comprehensive paper on the practical significance of tests on asphalt cements was prepared and presented by N. W. McLeod. Mr. McLeod spoke from the point of view of the highway or airfield engineer rather than the rheologist or chemist. Six basic engineering requirements noted were consistency, resistance to hardening or other physical and chemical changes, good affinity or adhesion for the aggregate, solubility in such solvents as carbon disulfide or carbon tetrachloride, safety in handling at high temperatures, and uniform characteristics. The author also reviewed the commonly used physical tests generally referred to in specifications. He concluded that specifications for asphalt cements should be restricted to those items that can be related to asphalt performance. Such items as softening point, specific gravity, temperature susceptibility, ductility at 39.2 F, and viscosity are not required in specifications, whereas flash point, penetration, ductility at 77 F, and loss on heating should be required. Greater use of viscosity-temperature curves for asphalt cements was recommended.

Precision of present ASTM tests on bituminous paving binders was the subject of a paper by A. B. Brown. The adequacy of the precision of the test methods had been examined by Mr. Brown and found, in many cases, to be inadequate in clarity and coverage. The author found that, of 31 standards, involving 56 different tests, which should require precision statements, 19 had neither repeatability nor reproducibility clauses. In standards involving no bituminous components, of 21 requiring precision statements, 18 had neither repeatability nor reproducibility clauses. Mr. Brown recommended that: precision statements be

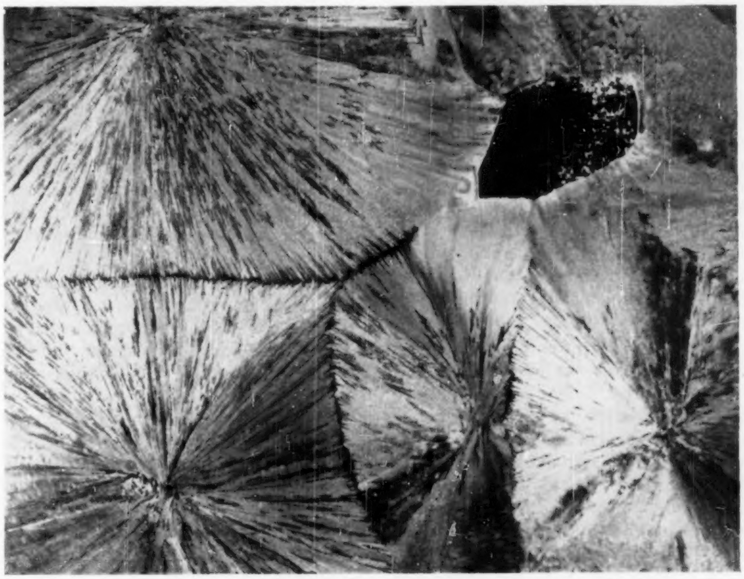
required in all Committee D-4 standards, the form of precision statement be standardized, subcommittees be encouraged or instructed to supplement existing standards with suitable precision statements, and the record of the supporting data for all precision statements either be published in the ASTM *Proceedings* or filed at Headquarters.

The need for statistical procedures to have essentially the same meaning for all who use them was stressed by P. E. Ireck in his paper, "Fundamental Statistical Concepts in Testing." The author reviewed several concepts, including that of the experimental universe in which the universe depends upon a space-time environment, experimental units, and the manner in which units are laid out. A second concept was that of the statistical model, which is a mathematical representation for associations among universe variables. The author confined his paper to the details of a "simple" illustrative investigation in which he incorporated many generalities of statistical methodology.

Bituminous Paving

Mix Design Discussed

This symposium contributed to the paving industry by relating various



Spherulitic Growth of Sugar

These aggregates of small needles were obtained by very slow crystallization of sugar in jello. They reveal the radial arrangement of crystal needles known as "spherulites." The picture was taken with a polarizing microscope. Magnification 9 ×. Second Prize, Photomicrographs, Black and White—Plastics. Eleventh ASTM Photographic Exhibit. Libera M. Dogliotti, Headquarters, Quartermaster R & E Command, Natick, Mass.

Symposia and Sessions

ASTM test methods to actual design of bituminous paving mixtures. The symposium was opened by a paper on general factors in the design of bituminous paving mixtures presented by Prof. L. F. Rader. Professor Rader reviewed briefly the significant properties required of bituminous paving mixtures: stability, density, durability, flexibility, resistance to skidding, and workability during construction. He stressed the importance of optimum bitumen content and of economy in design.

J. L. McRae and C. R. Foster collaborated in preparing a paper on "Theory and Application of a Gyratory Testing Machine for a Hot-Mix Bituminous Pavement," presented by Mr. McRae. The kneading-type machine was developed by the Texas State Highway Department for laboratory compaction and further expanded to permit mechanical compaction of specimens to any given field condition. Mr. McRae stated that this equipment can be used to evaluate the plastic properties of specimens directly during the compaction process and thus indicate the optimum asphalt content.

The Marshall test method has received increased use in the design of hot-mix bituminous pavements. This has led to a study of the reproducibility of test results using this apparatus in a number of locations. H. L. Lehmann and V. Adam, in a paper presented in their absence by J. M. Rice, described an investigation involving different operators, hand mixing and mechanical mixing, heating of the breaking heads to 140 F, and the effect of viscosity of the asphalt. The authors concluded that the Marshall apparatus is simple, portable, and inexpensive and, therefore, a valuable tool in hot-mix design and control.

"Control of Bituminous Shoulder Construction for the Northern Illinois Toll Highway," by J. J. Waddell was an interesting account of the experiences encountered in this highway project. The Marshall test method was used on this project to design the asphaltic concrete. Special specification requirements established for this usage were presented in the paper. The author reviewed the inspection and control routines followed. He stressed adequate training of inspectors and stated that control should start at the refinery and quarry.

The use of the triaxial shear strength method of test has been known and used for the past 25 years. W. H. Goetz and J. H. Schaub summarized the status of triaxial testing as a design and research tool and reviewed the various triaxial testing procedures now in use. The theory of triaxial testing is relatively simple, it being described as a compression test performed with the test specimen warped by a confining pressure. Mr Goetz, in presenting the paper, emphasized that one of the major problems encountered in using the triaxial test for evaluating is that the procedure has not been adequately standardized. There is even lack of agreement on nomenclature. Further research is needed to establish a familiar basis for the use of this method in the design of bituminous mixtures.

"Correlation of Hveem Stabilometer and Cohesiometer Test Results and Kneading Compactor Densities with Service Records of Bituminous Pavements" was the title of a paper by C. E. Minor, presented in his absence by L. F. Rader. The author pointed out that bituminous pavements respond to their environment in a variable fashion. One pavement may withstand the rigors of traffic during the winter and fail the next summer when its surface temperature may reach 150 F. Another pavement may perform satisfactorily in the summer but show severe abrasion or raveling in the fall and spring. The experience of the Washington State Highway Commission, which is required to meet varying conditions, has found this variation in the mild and moist coastal plains as contrasted with the much drier and seasonal hot and cold plateau to the east. Density is a very important property in pavement mixtures, and the Hveem stabilometer and cohesiometer were very useful and provided excellent tools for designing bituminous mixtures.

Void requirements for determination of graded bituminous paving mixtures was the subject of a paper presented by M. W. McLeod. In stressing the two basic objectives of sound bituminous paving mixture design, stability and density, the author stated that one property is apt to be ignored in considering the other. Pavement durability requires careful consideration of the void properties. The determination and evaluation for air voids and volume of void space between aggregate particles was discussed thoroughly by the author, who listed the advantages and disadvantages of calculating these values. Extensive discussion reflected the interest in this paper.

The use of the immersion-compression test was described by J. F. Goode, Jr. Mr. Goode presented the background of this test, cited some of its important uses in evaluating bituminous paving mixtures, and gave the important factors to be considered in designing bituminous mixtures. Stability was measured by the compressive-strength portion of the immersion-compression test. Flexibility was taken into account by setting the asphaltic content at its maximum practical value and by limiting the maximum amount of dust. An important feature of the design procedure was described, this being the use of the Rica vacuum saturation method of determining maximum specific gravity of the mixture and effective specific gravity of the aggregate for use in evaluating air voids.

Soils

Soil-Cement Mixtures Studied

The performances of two "substandard" granular materials when treated with various quantities of cement and one "acceptable" material without cement additions were tested using the bearing ratio and soniscope tests over a period of 5 years' exposure in the Chicago area. These tests confirmed the data from the wetting-and-drying tests (Method D 559) and freezing-and-thawing tests (Method D 560) in suggesting that cement contents less than those indicated by the ASTM procedures were not adequate for conditions of exposure to severe freezing and thawing. In the session on soils, M. S. Abrams presented considerable data using these tests over the 5-yr test period.

The laboratory investigation reported by D. T. Davidson, G. Noquera, and J. B. Sheeler was undertaken to determine the effect of the form of lime mixtures used in soil stabilization. The authors found that to be most effective, quicklime should be applied only as a slurry and hydrated lime may be applied either as a powder or as a slurry. Dolomitic limes were found to give higher strengths for stabilization than do calcitic limes.

The unusually sharp change in the compressibility of the Leda clay at the preconsolidation load and its measurement was described by J. J. Hamilton and C. B. Crawford. Settlements in the metropolitan area of Ottawa built on this clay and the settlement of the National Museum in particular have prompted this study. Field and laboratory test data have shown that extreme care in sampling and handling test specimens is necessary; when load increments are large, estimates of the

most probable preconsolidation pressure are too low and initial water content of specimens affects the slope of the compression curves. A systematic method of determining the end of the primary consolidation under load increment was developed by the authors. The data presented indicate that the leaching of salt from pore water after deposition has led to a metastable structure in the Leda clay and that this change prevents the determination of the geological pressure-void-ratio curve by laboratory testing and is responsible for the extremely high compression indices found in virgin compression.

Time Rates of Loading

Varied Attack on Problem

The problem of the mechanics of soil, an engineering material highly influenced by time-rates of loading, was attacked in a variety of ways in the Annual Meeting symposium.

W. S. Housel noted that dynamic and static resistance of soil has been recognized as a problem of major importance in the engineering use of soil for over 100 years. He discussed three methods of measuring permanent static shearing resistance of soils: incremented loading at constant time intervals and yield value determination by extrapolating to zero; the determination of minimum and maximum soil resistance coefficients derived from settlement and stress reactions in linear equations for bearing capacity; and the determination of the elastic properties of piles and supporting soil to find the loads carried at the elastic limit.

The Leda clay, a marine deposit underlying metropolition Ottawa, Canada, is a highly plastic, highly compressible, and highly stratified clay, with plasticity, grain size, and water content varying appreciably over a few inches vertically. C. B. Crawford selected one homogeneous layer of this clay and made a number of triaxial compression tests with pore water pressure measurements. These tests suggest that a structural breakdown controls the level of pore water pressure which appears to be related to the rate of strain. The implications of this phenomenon became apparent when the test results were plotted on a Mohr diagram of stresses. It was shown that the Mohr failure envelope is significantly influenced by testing time.

W. Ellis and W. G. Holtz showed that by maintaining a record of the pore pressure *versus* volume change, a relationship at regular intervals of axial loading has provided a suitable and convenient means for controlling the rate of testing. When this rate is followed, good agreement between shapes of the theoretical and measured pore pressure *versus* volume change curves are obtained. This reflects the true pressure conditions of the pore fluid within the test specimen.

An apparatus for subjecting specimens to repeated triaxial compression, the stresses being rapidly applied and removed with negligible impact effects, was described by H. B. Seed and J. W. N. Fead. This apparatus has suitable controls to regulate the magnitude and duration of load, and the interval between load applications.

Although creep phenomena are seldom significant in most engineering materials, except at elevated temperature, clay and soils exhibit significant creep in their performances at ordinary working stress levels. D. Burmister pointed up three fundamental stress-strain relations: hydrostatic compression, consolidation, and triaxial compression, and noted that creep phenomena can occur in all three of these relations.

G. A. Leonards and B. K. Ramiah studied samples of remolded clay to investigate the effects of rate and duration of loading on the compressibility and rate of compression of clays. They noted that after a period of rest (with or without secondary compression), the interpretation of subsequent compression is critically dependent on the pressure increment ratio used—at small pressure increments, a quasi-preconsolidation pressure is observed that is considerably larger than the maximum previous consolidation pressure. The significance of this quasi-consolidation pressure was discussed.

An analytical basis for setting up stress-strain-time laws for soil materials was established by R. L. Schiffman. These laws are based on the conditions of visco-elastic stress-strain-time properties. This approach was applied to hydrostatic, unconfined, and triaxial-compression stress-strain-time laws.

Atterberg Limits

Classification of Soils Studied

A. Atterberg, a Swedish soil scientist, suggested in 1911 that clays could be classified according to the quantities of water required to produce certain limiting rheological conditions in the clay. He suggested six limits and one index number. Three of these limits and one index number are standardized in ASTM methods: liquid limit (D 423), plastic limit (D 424), shrinkage limit (D 427), and plastic index (D 424).

The Symposium on Atterberg Limits was a compressed presentation of nine excellent papers on the subject. Prof. E. E. Bauer opened the program with a brief paper on the history and development of Atterberg Limits tests. This was followed by an informative paper on "The Use of a One-Point Liquid Limit Procedure" by W. J. Eden, presented in Mr. Eden's absence by R. F. Legget.

"Correlation of Atterberg Limits with Geology for Deep Cores from Subsidence Areas in California" was presented by W. G. Holtz in the absence of the authors, A. I. Johnson and D. A. Morris. These data indicate good correlation between Atterberg Limits and the geology of the region. The authors pointed out that the one-point method of determining liquid limit gives results similar to the standard three-point method with substantially lower testing costs.

Prof. Raymond F. Dawson, in his paper, "Investigations of the Liquid Limit Test on Soils," concluded that the present liquid limit test is not satisfactory and if it is to be continued procedures should be revised and standardized. Using present test procedures, he reported variation in results ranging from ± 5 per cent to ± 10 per cent of the liquid limit.

James A. Mitchell presented a comparison of "Liquid Limit Results from Various Types of Grooving Tools." His tests compared the Casagrande grooving tool, the ASTM tool, and the Hovanyi tool. He concluded that all three tools could be used interchangeably for soil classification purposes without significantly affecting the classification of a particular soil. However, the tools should not be interchanged when testing for specification compliance since small differences in liquid limit could affect acceptance or rejection of a material. The Hovanyi tool, according to Mr. Mitchell, performed more satisfactorily than either the ASTM tool or the Casagrande tool on soils of low plasticity.

In a paper "Proposed Universal Standards for the Liquid Limit Tests" by M. D. Morris, Richard B. Ulp, and R. A. Spinna, the authors described concurrent studies made at two laboratories to determine some of the causes of the variations in the measured liquid limit of clays and made recommendations for a standard liquid limit test which would require changes in the present ASTM Method D 423.

E. A. Abdun-Nur described the cube method for determining plastic limit

Symposia and Sessions

of soils and outlined the history of the development of this method and its advantages. He also presented data comparing results by this method and by the standard ASTM thread method and developed a correlation between the two. He concluded that the cube method has a high degree of correlation with the thread method and may be used interchangeably with it. The cube method was originally devised by J. C. Russell in about 1930 for testing soils for agricultural purposes. It was adapted to engineering testing of soils in the Nebraska area by Ira B. Mullis and W. J. Turnbull about 1932.

In their paper, "Penetration Tests for Liquid Limit," G. F. Sowers, A. Vesic, and M. Grandolfi suggested a procedure for further study of the use of a standard cone as a penetrometer point in determining the liquid limit of soils. They reported that experiments with cone penetrometers to establish a liquid limit test have been undertaken in at least four nations: U.S.S.R., Bulgaria, India, and the United States. Although these studies apparently began independently, the apparatus used and the results obtained have been both similar and consistent, and they conclude that the cone shows great promise as a simplified liquid-limit test device.

Water-Formed Deposits

Problem: Identify and Eliminate

Water-formed deposits often constitute a major problem, particularly in boilers and in power plants. To cope with this problem one must identify the deposits. At the Symposium on Water-Formed Deposits, the problem was stated from the viewpoint of the water-treatment engineer. This was followed by a thorough discussion of the methods currently in use for the identification of water-formed deposits and also a discussion of the correlation between elemental analysis and phase identification of deposits as an indication of the conditions under which the deposits were formed.

Individual papers in the symposium covered a general discussion of the problem and of the principles and methods involved; specific discussions of methods involving emission spectroscopy, electron microscopy and electron diffraction, and other instrumental methods; and correlation of elemental analysis and phase identification.

In addition to methods for identifying the deposits, the symposium papers dealt with the use of this information in determining the causes of the deposits and in finding means for solving the problems resulting from the deposits. It was shown that the use of a variety of methods in combination can yield the most useful information.

Microscopy

Versatile Tool Described

Developments in the field of microscopy in the past 25 years have called for much more refined laboratory techniques. Not infrequently the microscopist, in developing special methods to suit his purposes, is faced with the prospect of a long literature search. Authors at the Symposium on Microscopy discussed a wide variety of problems and the techniques used for their solution using all forms of the microscope—either light or electron.

The phase microscope permits the study of living organisms. O. W. Richards discussed its particular value in determining the thickness of transparent particles and in measuring refractive index. Using the attachments for interference microscopy, the optical path of transparent media may be measured, and from this one can compute the mass of reasonably homogeneous specimens. In the study of living organisms, this microscope can be used to determine the change in mass during the growth of yeast cells, changes in thyroid colloid, enzyme action, hemolysis, etc. Mr. Richards discussed variations in light sources for these studies, accuracy of observations and typical errors of observation due to physiological deficiencies.

The polarizing microscope is probably the most useful type of microscope for studying the structure of the new synthetic fibers. R. G. Scott reviewed in detail the elucidation of fiber structures using polarized light. The contributions of light and electron microscopes and the techniques developed for specimen preparation of these fibers were also emphasized.

Dispersion staining microscopy has proved to be of particular value for determining the refractive index of optical glass and plastics as used in the optical industry. Germain Crossman discussed this technique as an approach to determining areas of devitrification in optical glass and the nature of these defects. The petrographic microscope is used in the optical industry for study of grinding media and the constitution of dust.

The ore microscope, used to study opaque minerals by polarized light, is a basic tool used in the investigation of metallic ores. E. N. Cameron reviewed techniques of preparing the polished specimen, identifying minerals, and using the ore microscope.

The electron microscope, as used by the petroleum industry, has made possible tremendous progress in characterizing soap structures and correlating them with the physical properties and behavior of greases. H. M. Allred discussed the study of lubricating greases, the determination of the presence of clay and catalyst particles, oxidation products, organic crystals (such as waxes or soap), and additives in petroleum products. Mr. Allred pointed out that significant changes in the dispersancy of an oil for use in engines can be detected by the electron microscope long before they become apparent by other tests.

The electron microscope now has a resolving power as low as 8 Å with direct observation. This resolution has made direct examination of clays and other extremely fine-grain materials of particular value in determining the morphology of the individual particles. In order to fully utilize the microscope, new carbon-evaporation techniques had to be developed for clay particle replicates. J. J. Comer reviewed many new techniques and indicated that possibilities for further fruitful work in this area are almost limitless.

Multiple-beam microinterferometry is possible with almost any microscope fitted with a vertical illuminator and a monochromatic light source. S. B. Newman discussed this and other techniques for studying the origin of cracking or crazing, surface erosion, and fracture of plastics.

Optical and electron microscopy have both increased our understanding of the cotton fiber and its response to common textile processing treatments. M. L. Rollins, I. V. de Gruy, V. M. Tripp, and A. T. Moore described and illustrated the structure of the cotton fiber and what happens to this structure following physical treatments such as mercerization, coating, or impregnation, and chemical modifications such as acetylation and etherification.

Supplementary tools for light and electron microscopical observations were emphasized by C. F. Tufts. X-ray and electron diffraction, and X-ray and emission spectroscopy were reviewed in terms of their contribution to the elucidation of specific problems of microstructure of metals used in electronic devices. Mr. Tufts discussed use of orthoscopic and conoscopic observations in transmitted and reflected light.

Stainless Steel

Valuable Design Data

With high temperatures forcing the use of more and more stainless steel in airframe structures, where once the lighter metals ruled supreme, much energy is now being devoted to studies of its mechanical properties and its reaction to various types of environment. In the five papers heard at the Session on Stainless Steel, much valuable engineering information was presented.

R. R. Brady reported that type 304L steel with about 0.16 per cent nitrogen has (1) intergranular-corrosion resistance equal to that of the same steel with normal nitrogen content and (2) tensile and creep rupture strength, at temperatures from room to 1500 F, equal to that of the high-carbon type 304 steel. A study of the effect of stress relief on the static tensile notch sensitivity of types 301 and 304ELC steel sheet was reported by W. F. Brown, Jr. He concluded that none of the stress relief treatments studied had any pronounced effect on the notch sensitivity.

A. Kasak presented a nomograph for estimating the room- and elevated-temperature properties of austenitic Cr-Mn-C-N steels. He reported that the use of the composition and heat treatment design principles represented by this nomograph would make possible the design of steels with specific ranges of properties.

Properties of cast and forged Cr-Mn-Ni-N steels containing 18 per cent chromium were reported by J. J. Kanter. Studies included phase relationships, nitrogen solubility (liquid-solid), forgeability, castability, mechanical and corrosion properties, and embrittlement. A multiple-regression analysis, reported by K. H. Kramer, was used to study the effect of composition and processing variables on some mechanical properties of large Ni-Mo-V rotor forgings. Mr. Kramer described the effect on impact and tensile properties of carbon, manganese, molybdenum, phosphorus, nickel, and chromium content, and of austenitizing and tempering temperature.

Use of Radioisotopes

Neutron Sources Generally Available Soon

The increasing use of analytical methods involving radioisotopes and the prospects for much greater use of such methods were dealt with in the Symposium on Radioisotopes in Metals Analysis and Testing. While the use of radioactive tracers, including isotope dilution techniques, was by no means neglected, even greater consideration was given to the present and potential capabilities of activation techniques in which the sample to be analyzed is irradiated in such a way that the sample can then be analyzed by measuring the radioisotopes created in the sample and evaluating the results. Much more compact and much less expensive neutron sources that can easily be installed in individual laboratories should become generally available within a year. Such neutron sources will greatly increase the convenience and reduce the expense of activation techniques. Measurements based on isotopes having a very short half-life will be practical for the many laboratories not having convenient access to an atomic reactor. For that matter, the number of research reactors is expected to increase considerably within the coming year.

In the introduction to the symposium, Prof. W. W. Meinke covered the principles, available techniques, capabilities, and problems involved in the use of radioisotopes in metals analysis and testing. Detailed discussions of

the various types of instrumentation and techniques were presented in a paper by A. H. Emmons.

A general coverage of metals analysis by radioactivation techniques was given in a paper by G. H. Morrison. Specific applications of radioactivation techniques were covered in papers by J. F. Cosgrove, A. H. Bushey, and J. E. Lewis. The importance of standard samples in activation techniques was brought out in these papers. Referee analysis by means of isotope dilution methods was described by C. Rosenblum.

The practical problems of training industrial personnel in the use of radioisotopes were covered by J. P. Danforth. In addition to technical training, the need for the ability to sell this type of work to management and for good public relations was brought out.

The intense interest in the symposium was evidenced by an hour-long panel discussion that followed the

Fatigue Cracks in a Fine-Mesh Stainless Steel Screen

Magnified view—by Nestor J. Shimshock, The Detroit Edison Co., Detroit, Mich. The subject stainless steel screen is used on strainers in main steam piping, and is fine-mesh by standards of the power industry.

Symposia and Sessions

evening session and covered specific problems in installing equipment and techniques for using radioisotopes.

Spectroscopic Excitation

New and Improved Sources

Excitation is one of the most important variables in emission spectroscopic analysis. The matrix effect in excitation, the effects of gaseous atmospheres on excitation, and some properties of new or modified excitation sources were covered in the Symposium on Spectroscopic Excitation by the authors, J. K. Hurwitz, G. Anderman, J. W. Kemp, and M. Margoshes. Extensive discussions of these papers added greatly to their value.

While the effect of matrixes on determinations of elements is well known, an unusually clear and complete discussion of this effect was given in the symposium paper on this subject. Equally comprehensive was the treatment of the effects of gaseous atmospheres on excitation.

The paper on properties of excitation sources dealt largely with sources that might permit greater precision and accuracy in the determination of major constituents, with considerable discussion of improved sources for use in flame photometry. High energy sources such as the Gerdien arc and the plasma jet were also covered. The fluid stabilized arc was considered to hold much promise.

Fatigue

Needed: Fundamental Knowledge, Faster Answers

The complex phenomenon that we have tied up in the package labeled "fatigue" is a bundle of unanswered questions. Although we are far from a complete understanding of the basic mechanism of fatigue damage, engineers nevertheless must have design criteria.

Much of the hardware now being flung into space is subjected to very severe, but short-time, vibratory loading, usually at elevated temperatures. Therefore the search is on for a design criterion for "low-cycle" fatigue. Jules Brinn presented the paper, "Some Observations of the Plastic Work Required to Fracture Stainless Steel Under Cyclic Loading," by D. E. Martin and Mr. Brinn. The authors described tests made on AISI type 347 stainless steel at 1000 F under completely reversed axial load. Periodic stress-strain records were taken throughout each test by an oscilloscope, and the plastic work per cycle was obtained from the hysteresis loop. The authors suggested that plastic work, rather than stress level, is the thing to use for low-cycle fatigue design. They devised a relationship involving stress level, total plastic work required to produce fracture, and experimentally derived constants, which they feel to be a starting point for further studies of the mechanism of low-cycle fatigue.

The "depletion of ductility" concept of fatigue damage was questioned by J. Marin, P. Borachia, and U. A. Rimrott in their paper, "The Effect of Stress Cycling on the Static Mechanical Properties of SAE 4340 Steel," presented by Mr. Rimrott. The authors precycled axial-load specimens in tension, with zero stress ratio, to various percentages of their fatigue life, and then tested the specimens statically to determine the effect of the precycling on the static tensile properties. The effects were small. The authors therefore argued that, since ductility, as measured by reduction of area, is affected very little by large amounts of precycling, their results do not support the "depletion of ductility" theory of fatigue damage.

Nature yields fatigue data very reluctantly. The experimenter must pay in time and patience for every piece of data he turns over to the designer. Thus far, no "quickie" method satisfactory to all has been found, although it is not for lack of trying. N. Enomoto, in his paper, "A Method for Determining the Fatigue Limit of Metals by Means of Stepwise Load Increase Tests," presented by H. T. Corten, described rotating-beam tests using carbon steel specimens, on which the load was increased in steps during the test. This is similar to the well-known Prot method, in which the load is increased uniformly. The author pointed out that stepwise load increases are much easier to apply than uniform load increases, and reported no substantial difference in results using the two methods.

Another way to shorten the time required to get results is to speed up the test. In his paper, "Techniques and Equipment for Fatigue Testing at Very High Frequencies," presented in abstract by A. Q. Mowbray, E. A. Neppiras reviewed practical design criteria for fatigue test systems operating at ultrasonic frequencies, using piezoelectric, piezomagnetic, and electrodynamic transducers. The mechanical and electrical features of drive systems as well as the design of various types of specimens are described in the paper.

General Testing

Hardness Testing of Cemented Carbides

Rockwell hardness has been used by industry as a general acceptance test for cemented tungsten carbide. However, serious discrepancies in test data obtained by producers and their customers led to an intensive effort to standardize hardness testing procedures for these very hard, brittle materials. The results of a cooperative testing program undertaken by several cemented carbide producers and one hardness machine manufacturer were presented in a paper, "A Cooperative Study of the Hardness Testing of Cemented Carbides," by Betty M. Caugherty, H. T. Oatman, and O. W. Reen. The authors presented a statistical analysis of the results and showed the expected range of variability between tests by two companies. Variables present in the hardness testing of cemented carbides were explained. These include the variables due to the machine, its operation, its operator, and to the metallurgical differences present in the test blocks.

Estimating Corrosion Rate

A method for determining corrosion rate from electrochemical measurements was described in the paper, "Experimental Observations on the Relation Between Polarization Resistance and Corrosion Rate," by Milton Stern and Edward Weisert. The authors showed that corrosion rate is inversely related to polarization resistance. For most corroding systems, the corrosion rate can be estimated to within a factor of 2 by a simple measurement of the current required to polarize a few millivolts. Data from a variety of published sources, along with a number of new observations, were used to support the correlation. The data extended over six orders of magnitude. While the use of polarization resistance to determine corrosion rates cannot be considered a universal approach, there is sufficient basis in theory along with supporting evidence to believe that the technique will find a particularly useful place in corrosion measurements.

New Testing Machine for Sealants

The development and increase in use of new sealing compounds in building construction has created problems in testing. Available testing machines do not provide needed information on all the qualities of these new joint sealing

compounds. As these new materials, particularly the new elastomeric sealers, brought increased capabilities for sealing joints in concrete, curtain walls, and other types of building construction, it became desirable to develop a machine that would measure such properties as: force required to move a sealed joint through a given distance, pull strength at failure, compression set, compressive capacity of nonelastomeric materials, and fatigue. It was also felt that the machine should be capable of applying loads at varying rates and through varying distances, and that it be portable so that the test could be carried out at constant temperatures, in low- or high-temperature control rooms, or in high-humidity rooms. A machine fulfilling these requirements was described in the paper on "New Joint Testing Machine Developed," by R. J. Schutz and A. Van Hauter.

Product Appearance

Television to Be Useful?

Closed-circuit television and color photography are two of the tools which are fast becoming important to industry as aids in standardizing and communicating product appearance. These as well as other methods of appearance evaluation were described at a symposium sponsored by Committee E-12 on Appearance.

I. Nimeroff first surveyed present ASTM methods and standards for appearance evaluation. Sight is the most reliable of our senses, he stated, and can discriminate smaller appearance differences than most instruments developed to date. This is reflected in the fact that visual inspection methods, including both casual and controlled, outnumber instrumental methods. He suggested that future efforts of Committee E-12 be put forth to unify, simplify, and generalize these appearance standards.

In a paper entitled "Visual Aids in the Textile Industry," J. B. Goldberg described the use of photographs to illustrate fabric defects, to identify types of fabrics, and to grade textile materials in such characteristics as water repellancy and colorfastness. With the introduction of the wash-and-wear fabrics, a need to evaluate wrinkle resistance led to the development of photographic standards and later to three-dimensional plastic patterns for illustrating varying degrees of wrinkling.

One of the most intriguing of the newer aids to visual inspection is closed-circuit television. R. Vendeland described such uses as transmitting images from inaccessible or hazardous locations. Another present use is in the inspection of cutting edges of blades. Imperfections are magnified electronically; here, television replaced the microscope. Perhaps one of the most spectacular possibilities illustrated by Mr. Vendeland was the translation of shades of gray by the television camera to differences in color by means of a color converter.

A color photograph of a re-entry test of a missile nose cone was one of a group of interesting slides used by J. R. Kane to illustrate his paper on the "Use of Color Photography for Product Specification and Control." A photograph of this type can be used to show temperature variations and turbulence. One

of the first applications of the use of color photographs was in assisting semiskilled workers to wire television sets from photographic transparencies or prints of the finished sets, using colored wires. The speaker emphasized, however, that certain precautions must be taken with both materials and procedures. Processing emulsions may vary as much as half a stop from batch to batch, and high temperature and humidity have a deleterious effect on stored film.

These Annual Meeting Papers Are Still Available

Some of the papers which were not preprinted for the 1959 Annual Meeting were mimeographed primarily for the use of those interested in presenting discussion. A limited number of these are available from ASTM Headquarters, 1916 Race St., at a nominal charge.

Studies of Limestone Aggregates by Fluid-Flow Methods—W. L. Dolch
Control Testing for Separation of Lightweight Materials from Aggregate—E. C. Higginson and G. B. Wallace
Concrete for Shielding Nuclear Radiations—H. S. Davis
Dynamic and Static Resistance of Cohesive Soil—1846 to 1958—W. S. Housel.
The Effect of Rate of Strain on Effective Stresses in Sensitive Clay—C. B. Crawford
A Method for Adjusting Strain-Rates to Obtain Pore Pressure Measurements in Triaxial Shear Tests—W. Ellis and W. G. Holtz
Strain-Rate Behavior of Clay and Organic Solids—D. Burmister.
The Use of Visco-Elastic Stress-Strain Laws in Soil Testing—R. L. Schiffman.
Anisotropy of Crack Initiation and Propagation in Cold Rolled Aluminum Sheet—H. A. Lipsitt, F. W. Forbes, and R. B. Baird.
Tensile and Fatigue Properties of Laminate Sheet Structures—R. B. Baird, F. W. Forbes, and H. A. Lipsitt.
Powder vs. Slurry Application of Lime for Soil Stabilization—D. T. Davidson, G. Noguera, and J. B. Sheeler.
General Factors in the Design of Bituminous Paving Mixtures—L. F. Rader.
Application of Marshall Method in Hot Mix Design—H. L. Lehmann and V. Adam.
Stress-Strain Properties of Selected Titanium—E. P. Klier and C. Gazzara.
Properties of 70–30 Copper-Nickel Alloy at Temperatures Ranging up to 1050 F—W. F. Simmons, R. I. Jaffee, D. N. Williams, and B. J. Sirois.
The Use of a One-Point Liquid Limit Procedure—W. J. Eden
Ohio Adopts the One-Point Mechanical Method for Determining the Liquid Limit of Soils—J. G. Joslin and H. D. Davis
Investigations of the Liquid Limit Test on Soils—R. F. Dawson.
Liquid Limit Results from Various Types of Grooving Tools—J. E. Mitchell.
Triaxial Testing of Bituminous Mixtures—W. H. Goetz and J. H. Schaub.
Correlation of Hveem Stabilometer and Cohesiometer Test Results and Kneading Compactor Densities with Service Records of Bituminous Pavements—C. E. Minor.
Void Requirements for Dense Graded Bituminous Paving Mixtures—N. W. McLeod.
The Use of the Immersion-Compression Test in Evaluating and Designing Bituminous Paving Mixtures—J. F. Goode.
Experimental Observations on the Relation Between Polarization Resistance and Corrosion Rate—M. Stern and E. D. Weisert.
Effects of Gaseous Atmospheres on Excitation—G. Andermann and J. W. Kemp.
Some Properties of New or Modified Excitation Sources—M. Margoshes.
A Preliminary Report on Sharp Edge Notch and Smooth Tensile Characteristics of Ultra High Strength Steel Sheet Alloys—G. B. Espey, M. H. Jones, and W. F. Brown, Jr.
Practical Significance of Tests on Asphalt Cements—N. W. McLeod.
Precision of Present ASTM Tests on Bituminous Paving Binders—A. B. Brown
Fundamental Statistical Concepts in Testing—P. E. Irick.
Control of Gypsum in Portland Cement—B. Tremper.
Cement Reference Laboratory (1929–1959)—J. R. Dise.
The Use of Capillary Viscometers and Fundamental Viscosity Units as a Substitute for the Saybolt Furol Viscometer for Practical Refinery Control of Cutback Asphalt Production—D. V. Levy, F. E. Fassnacht, R. D. Umbach, G. P. Hibler, and D. C. Gagle.
Density Changes in Asphalt Pavement Core Samples—T. C. Hein and R. J. Schmidt.
Application of Electron Microscopy in the Petroleum Industry—H. Allred.
Application of Emission Spectroscopy to the Analysis of Water-Formed Deposits—C. H. Anderson.
Identification by Instrumental Methods of Chemical Compounds in Water-Formed Deposits—C. M. Maddin and R. B. Rosene.
Correlation of Elemental Analysis and Phase Identification as Viewed by a Mineralogist—J. V. Smith.

ASTM Elects New National Officers

President LaQue

Vice-President Clair

F. L. LaQue has been a vice-president of the International Nickel Co., Inc., and manager of its Development and Research Division since June, 1954. He had previously been head of the Corrosion Engineering Section of that division since 1945.

A native of Gananoque, Ont., Mr. LaQue received his B.S. in chemical and metallurgical engineering from Queen's University, Kingston, Ont., in 1927. He joined the International Nickel Co.'s Development and Research Division that year and since then has devoted his activities to the field of corrosion and corrosion-resisting materials. He was assistant director of technical service on mill products from 1937 until April, 1940, when he became engaged in development activities on all applications of both ferrous and non-ferrous nickel-containing alloys. Under his leadership, the well-known corrosion testing stations of the company at Kure Beach and Harbor Island, N.C., were established.

He has been an ASTM member since 1935. In 1951 he delivered the Edgar Marburg Memorial Lecture on "Corrosion Testing." Mr. LaQue has served as vice-president of the Society since 1957 and also has served on the following Board of Directors committees: Executive, Finance, Special Administrative Committee on Nuclear Problems, and Committee on Government Contacts. For many years he was a member of the Administrative Committee on Papers and Publications and presently holds membership on several technical committees.

In 1949, Mr. LaQue received the F. N. Speller Award in Corrosion Engineering of the National Assn. of Corrosion Engineers, of which he is past-president.

He is vice-president of the Electrochemical Society, a member of the American Chemical Society, American Society for Metals, American Association for the Advancement of Science, chairman of the Corrosion Research Council of the Engineering Foundation, and serves on Visiting Committees of the Massachusetts Institute of Technology and Case Institute of Technology. He also is a member of the Advisory Committee of the School of Metallurgical Engineering of the University of Pennsylvania, and a member of the Advisory Panel to the Metallurgy Division of the National Bureau of Standards. Mr. LaQue is the author of numerous articles and papers on corrosion.

Miles N. Clair is president of The Thompson & Lichtner Co., a consulting and management engineering firm of Brookline, Mass. A native of Pennsylvania, he was educated at Drexel Institute of Technology (B.S. in engineering, 1921) and at Massachusetts Institute of Technology (S.M. C.E., 1923). He taught civil engineering at Drexel from 1923 to 1925 and joined the Thompson & Lichtner Co. in 1925 as engineer in charge of testing and inspection. He became vice-president in charge of engineering in 1928, and in 1930 was elected first vice-president and treasurer. He was elected president of the company in 1950.

Mr. Clair first became associated with ASTM in 1927 as representative of The Thompson & Lichtner Co., on Committees C-1 on Cement and C-9 on Concrete and Concrete Aggregates. He still serves on both and also represents his company on Committee D-18 on Soils for Engineering Purposes. Mr. Clair represents ASTM on the ASA Construction Standards Board and serves as vice-chairman. He is a member of the ASTM New England District Council and has served on the Administrative Committee on District Activities since 1949, becoming chairman in 1958.

Mr. Clair has been instrumental in the development of lightweight concrete roof slabs and the use of concrete made with fine and coarse cinders for structural purposes. His firm has been associated with many important construction projects in the United States and abroad.

He is past-president of the New England Section, ASCE; past-president of the Boston Society of Civil Engineers; past-director, American Concrete Institute, which he represents on ASA Sectional Committee A1; a member of ASA Committee on Reinforced Gypsum; Tau Beta Pi, and Phi Kappa Phi. He is a recipient of the Clemens Herschel Prize Award. He is the author of numerous technical papers and sections of engineering texts and handbooks.

Mr. Clair is active in many civic organizations. He recently received the Bronze Keystone award for his services to the Boys Club of America. He is past-president of the Boston Area Salvation Army Advisory Board and president of the Salvation Army Assn.; National Councillor of the USO representing New England; and member of the committee to revise the Boston building code section on concrete.

A. B. Cornthwaite, Director

A. B. Cornthwaite has been engineer in charge of the Materials and Testing Division of the Virginia Department of Highways since 1951. He joined the Highway Department in 1929 as a junior chemist, following his graduation from DePauw University where he received his B.A. degree in chemistry. His formal education was supplemented by additional courses in chemical and highway engineering.

In his present position, Mr. Cornthwaite is responsible for testing and approving materials used in constructing and maintaining Virginia's 49,000-mile highway system. He also works closely with the Virginia Council of Highway Investigation and Research at Charlottesville, which is sponsored jointly by the Highway Department and the University of Virginia.

Mr. Cornthwaite has been the Virginia Department of Highways representative in ASTM since 1952. His committee memberships include C-9 on Concrete and Concrete Aggregates; D-4 on Road and Paving Materials, of which he is chairman; and D-18 on Soils for Engineering Purposes. He is vice-chairman of the Washington District Council of ASTM, of the Committee on Materials of the American Association of State Highway Officials, and of the Bituminous Division, Department of Materials and Construction of the Highway Research Board.

Mr. Cornthwaite is also a member of the American Chemical Society and the Highway Research Board. He served as a lieutenant in the navy during World War II and holds a reserve commission.

C. L. Kent, Director

C. L. Kent is assistant director of technical services for the Jones & Laughlin Steel Corp., which he joined in 1927 after studies at the Carnegie Institute of Technology. He has been active in the metallurgical field since joining the company and served as laboratory director, metallurgical engineer, 1946 to 1955. In 1955 he was promoted to his present position.

He has represented his company on numerous ASTM Committees since 1946 including B-1 on Wires for Electrical Conductors; A-1 on Steel; A-5 on Corrosion of Iron and Steel, where he was particularly active in work on bar stock, pipe, and tubing; and the Section of Effect of Speed of Testing of Committee E-1 on Methods of Testing. In addition, he has served on the Pittsburgh District Council and has represented ASTM on ASA Sectional Committee B 31.

Mr. Kent is a member of the American Iron and Steel Inst., American Ordnance Assn., and the Society of Automotive Engineers. He is chairman of the AISI General Technical Committee and represents AISI on the ASA Standards Council.

H. C. Miller, Director

H. C. Miller is laboratory engineer in charge of the testing laboratory of Public Service Electric and Gas Co., Maplewood, N. J. A native of Ohio, he was graduated from Pratt Institute in chemical engineering in 1923.

Mr. Miller has been associated with Public Service Electric and Gas Co. since 1924, first in the Chemical Division of the testing laboratory, which he headed from 1930 to 1944 before becoming laboratory engineer in 1948.

He is his company's representative in the Society and has served on ASTM committees since 1930, notably Committee D-2 on Petroleum Products and Lubricants; Committee D-9 on Electrical Insulating Materials, Subcommittee IV, which is now Committee D-27 on Electrical Insulating Liquids and Gases; and on Committee D-19 on Industrial Water.

In addition to his ASTM committee work, he was active for many years on technical committees of Edison Electric Inst., such as its Power Station Chemistry Subcommittee and Prime Movers Committee, and has also served on a Power Test Code Committee of The American Society of Mechanical Engineers. He represents his company in ASTM; in the National Fire Protection Assn., and in the ASA.

C. F. Nixon, Director

C. F. Nixon is head of the Electrochemistry and Polymers Department of the General Motors Research Laboratories engaged in research and development work on adhesives, elastomers, plastics, and electroplating. He is a native of Pennsylvania. In 1919 he entered the University of Wisconsin, where he became interested in electroplating through the influence of his professor in electrochemistry, Dr. Oliver P. Watts. Graduation with a B. S. in chemical engineering was followed by six years in the laboratory of the Western Clock Co., Peru, Ill.

In 1929 he joined the Ternstedt Division of the General Motors Corp. as plating engineer. Later, as director of process engineering and laboratories and then as director of the Process Development Section, he was concerned with plating engineering, finishing with organic materials, die casting, and product and material testing. In January, 1952, he was transferred to the research laboratories and assumed his present position.

Mr. Nixon has been an ASTM member since 1936. He has been active on ASTM Committees B-7 on Light Metals and Alloys, B-8 on Electrodeposited Metallic Coatings, D-20 on Plastics, and the joint ASTM-SAE Committee on Automotive Rubber.

R. D. Thompson, Director

R. D. Thompson, chief development engineer for commercial and glass products of the Taylor Instrument Cos., Rochester, N. Y., is a native of Grand Rapids, Mich. He attended the public schools of Grand Rapids and the University of Michigan from which he received a B.S.E. in chemical engineering and mathematics and a Ph.D. in chemistry. After a period as re-

search assistant in chemistry at the university, he was awarded one of the first Horace H. Rackham Post-Doctoral Fellowships. As a Fellow at the National Bureau of Standards, Dr. Thompson participated in the Bureau's fundamental study of the thermodynamic temperature scale. In 1938 he joined the Taylor Instrument Cos. where he has served successively as research chemist, manager of glass methods engineering, and chief development engineer for commercial and glass products.

Dr. Thompson has represented his company in ASTM since 1940. He is currently chairman of Subcommittee 17 on Thermometers and 18 on Hydrometers of Committee E-1 on Methods of Testing and is also a member of Committee E-1. In addition, he is a member of Section B on Gravity Determination of Research Division II of Committee D-2 on Petroleum Products and Lubricants, and has served as a councilor of the Western New York-Ontario District.


H. D. Wilde, Director

H. D. Wilde has been since 1957 research coordinator of the Humble Oil and Refining Co. He joined Humble Oil in 1927 in the Technical and Research Divisions at the Baytown refinery.

His early life was spent in Mexico, where his father was employed in the foreign service of the American Smelting and Refining Co. He received a B.S. in chemical engineering from the University of Texas in 1923, an M.S. from the same University in 1924, and a D.Sc. from the Massachusetts Institute of Technology in 1929.

Serving with the Humble Oil Co., he has held positions as head of production research work, manager of Product Research Division, and manager of Technical and Research Division. In 1945 he was made manager of research and development for the company as a whole, including work in geophysics and production.

Interested in the work of ASTM for many years, Dr. Wilde serves on the Southwest District Council of the Society and through representation of his associates on various technical committees.

Dr. Wilde is a member of the American Chemical Society; American Institute of Mining, Metallurgical, and Petroleum Engineers; American Institute of Chemical Engineers, and American Petroleum Institute. He served as a member of the AIME Board of Directors from 1938 to 1940.


I. V. Williams, Director

I. V. Williams is in charge of the Metals Engineering Group of the Bell Telephone Laboratories, with which he has been associated since 1926. He has been in charge of the group since 1942. He was graduated from the Pennsylvania State University in 1926 with a B.S. in electrochemical engineering.

Mr. Williams has been a member of ASTM since 1937 and active on many technical and administrative committees. He has been chairman of ASTM Committee B-7 on Light Metals and Alloys since 1946 and holds memberships on the Administrative Committee on Standards; the Long Range Planning Committee on Technical Committee Activities; the ASTM Ordnance Advisory Board; Committee A-1 on Steel; Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys; and the Advisory Committee on Corrosion. He represents ASTM on the SAE Non-Ferrous Metal Technical Committee.

He is also a member of the ASA Materials and Methods Board and until this year was chairman of ASA Sectional Committee B 32 on Standardization of Wire and Sheet Metal Gages.

Recently he was appointed chairman of the Committee on Material Requirements Criteria for Advanced Design of the Materials Advisory Board of the National Academy of Sciences-National Research Council.

Citations for Quality of Presentation

61st Annual Meeting—1958

APART FROM maintaining the technical quality of all papers presented at meetings of the Society, the Administrative Committee on Papers and Publications is also interested in having these papers well presented. There is a growing awareness of the importance of communication, particularly in the area of technical ideas and developments.

To foster improved communication and to make our technical sessions more interesting and thus more useful, each author is graded on the quality of his presentation. Reporters were assigned this task at the 1958 Annual Meeting. Based upon their reports, the four outstanding presentations for 1958 have been selected, and the following four authors are cited:

R. J. Diaz, West Virginia Pulp and Paper Co., Charleston, S. C., for presentation of his paper on "Clupak Paper—A New Type of High-Stretch Paper—Its Manufacture and Performance."

A. J. Duncan, associate professor of statistics, Johns Hopkins University, Baltimore, Md., for presentation of his paper on "Some Measurement Error Considerations in Bulk Sampling with Special Reference to the Sampling of Fertilizer."

R. J. Legget, director of building research, National Research Council of Canada, Ottawa, Canada, for presentation of his paper on "The Durability of Buildings."

K. T. Whitby, assistant professor of mechanical engineering, University of Minnesota, Minneapolis, Minn., for presentation of his paper on "Centrifuge Sedimentation Size Analysis of Samples of Airborne Dusts Collected in Membrane Filters."


R. J. Diaz


A. J. Duncan


R. J. Legget


K. T. Whitby

Honorary Members

Jerome Strauss

Douglas E. Parsons

The Society's Highest Honor

An Honorary Member is a person of widely recognized eminence in some part of the field which the Society covers or one who has rendered especially meritorious service to the Society. He is elected only by unanimous vote of the Board of Directors on a letter ballot.

Jerome Strauss, consultant, State College, Pa., and retired vice-president, Vanadium Corporation of America, New York, is a native of New York City. He was graduated from Stevens Institute of Technology in 1913 with the degree of M.E. with honors as valedictorian and winner of both the Priestley and the Stillman Prizes.

Following a year at the Illinois Steel Co., three years at the Western Drop Forge Co., and two years as a Lieutenant, Ordnance Department, U. S. Army, in World War I, he joined the staff of the U. S. Naval Gun Factory, Washington, D. C., in 1919 as assistant chief chemist and metallurgist, rising to the position of materials engineer. He became associated with the Vanadium Corporation of America in 1928 as chief research engineer, advancing to vice-president of research and development in 1935, and becoming vice-president and technical director in 1946—the position he held until his retirement.

A member of ASTM for 43 years, Mr. Strauss has been active in administrative work as well as the activities of many technical committees. He served on the Board of Directors from 1940 to 1942, the Committee on Papers and Publications in 1928 and 1929, the Pittsburgh District Council from 1931 to 1939, and the New York District Council 1950–1958.

Mr. Strauss has had wide experience in the alloy metal field both ferrous and non-ferrous, especially in the corrosion-resistant steels and the production and application of ferroalloys. He was chairman of ASTM Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys from its organization in 1929 until 1958. In recognition of his services, Mr. Strauss was elected Honorary Chairman of Committee A-10 in 1958. He has been active also on other committees dealing with ferrous and non-ferrous metals. His career qualified him admirably to present the second H. W. Gillett Lecture in 1953.

He is the author of many papers, reports, and articles in the metallurgical field, and he holds numerous patents. Other ASTM activities included representing the Society on Iron Alloys Research Committee of Engineering Foundation, on the Board of Directors of ASA (1940–1944), and on the Corrosion Research Council since 1956. Mr. Strauss served on the National Research Council's Gun Steel Committee during World War II.

Douglas E. Parsons, chief, Building Technology Div., National Bureau of Standards, received his A.B. degree in 1917 and his C.E. degree in 1923 from Cornell College, Iowa. From 1919 to 1923 Mr. Parsons was assistant engineer of the Iowa Railway and Light Co. and associated companies in Cedar Rapids, Iowa. He joined the staff of the National Bureau of Standards, Washington, D. C., as an associate engineer in 1923. He served as chief of the Masonry Construction Section from 1928 to 1945, chief of the Mineral Products Division from 1945 to 1946, and has been chief of the Building Technology Division since 1946.

Mr. Parsons has been a member of ASTM since 1924 and has actively participated in the building materials field. From 1937 to 1948 he served as chairman of Committee C-15 on Manufactured Masonry Units. He served as a Director of the Society from 1954 to 1957; as a member of the Administrative Committee on Simulated Service Testing, 1945–1949, and the Administrative Committee on Standards, 1947–1956; and has represented the Society on the International Association of Testing and Research Laboratories for Materials and Structures since 1957. In 1952 he received the ASTM Award of Merit. Mr. Parsons is the author of numerous technical papers and reports.

A member of several professional and technical societies, Mr. Parsons has been chairman of numerous committees, and has received many awards. He was president of the American Concrete Institute in 1945. In 1936 he received the ACI Wason Medal for noteworthy research; in 1952 he received the Lindau Award for outstanding contributions to reinforced-concrete design practice; and in 1959 he was awarded the ACI's highest award, the Turner Medal. Mr. Parsons is also a member of the American Society of Civil Engineers, the American Ceramic Society, the Highway Research Board, the American Association for the Advancement of Science, Society for Experimental Stress Analysis, the Building Research Institute, Philosophical Society, and the Washington Academy of Sciences.

Awards of Merit

V. E. Grotlisch

G. O. Hiers

THIRTEEN LEADERS in the field of engineering materials, who have rendered outstanding service to the American Society for Testing Materials, particularly in its technical committee work, were honored at the President's Luncheon with Awards of Merit.

Under the rules governing the Award of Merit, each technical committee may suggest one candidate annually, and the Award Committee may select nominees from other areas of the Society's work as well. While each of the award winners listed below was honored for intensive work and contributions in a specific technology, each has furthered in numerous ways the general activities of the Society.

To **Victor E. Grotlisch** *(retired) principal naval stores technologist and chief of the Naval Stores Branch, Agricultural Marketing Service, U. S. Department of Agriculture, Washington, D. C., in recognition of constructive and faithful service in technical committee work, especially as the long-time chairman of Committee D-17 on Naval Stores*

Mr. Grotlisch, a native of Cincinnati, Ohio, was graduated from the University of Cincinnati as a member of the first cooperative engineering class in 1912 with the degree of Chemical Engineer. For two years after his graduation, he taught chemistry, physics, and other engineering subjects at Rochester Atheneum and Mechanical Institute. He then joined Eastman Kodak Co. as analytical chemist in the plant control laboratory.

In 1914 he accepted appointment to the U. S. Department of Agriculture and remained with the Department until his retirement in March of this year—an association of 44½ years. From his initial appointment as junior chemist until his retirement as principal naval stores technologist and chief of the Naval Stores Branch, Agricultural Marketing Service, Mr. Grotlisch was engaged in all phases of chemical, engineering, development, statistical, administrative, inspection, standardization, and marketing work relating to turpentine, rosin, pine oil, and all other products of a chemical nature derived from the pine tree.

Mr. Grotlisch was chairman of ASTM Committee D-17 on Naval Stores from 1942 to 1958. He also represents this committee on Committees E-1 on Methods of Testing and E-8 on Nomenclature and Definitions and has been a member of Committee D-1 on Paint since 1931. He is the author of numerous technical papers.

To **George O. Hiers,** *consulting metallurgist (retired, National Lead Co.) Baldwin, N. Y., in recognition of long-time active participation in ASTM work, especially in the field of non-ferrous metals, and in Committee B-2 on Non-Ferrous Metals and Alloys, and for support of other ASTM technical and district work.*

Mr. Hiers, born in Brooklyn, N. Y., received his education at Brooklyn Polytechnic Inst. In 1911 he joined the National Lead Co. Research Laboratories as a metallurgist. He went into semi-retirement in 1951 after 40 years' service and is now a consulting metallurgist.

Mr. Hiers has been a member of ASTM since 1929 and has served on numerous technical committees including: B-2 on Non-Ferrous Metals and Alloys (since 1957 vice-chairman and secretary of Subcommittee III on White Metal Alloys); A-5 on Corrosion of Iron and Steel; B-3 on Corrosion of Non-Ferrous Metals; B-5 on Copper and Copper Alloys; B-6 on Die-Cast Metals and Alloys; B-7 on Light Metals and Alloys; E-1 on Methods of Testing; E-4 on Metallography; and E-8 on Nomenclature and Definitions.

His other society memberships include: Fellow, American Association for the Advancement of Science; American Chemical Society; American Institute of Mining, Metallurgical, and Petroleum Engineers; American Society for Metals; The American Society of Mechanical Engineers; National Association of Corrosion Engineers; Society for Automotive Engineers; New York Academy of Sciences; and Metal Science Club (New York). Mr. Hiers is the author of numerous articles on lead, tin, antimony, zinc, and other non-ferrous metals.

To **Elmer G. Kimmich,** *chief engineer, industrial products development, Goodyear Tire and Rubber Co., Akron, Ohio, in recognition of outstanding and sustained service in ASTM technical work, especially long-time support of Committee D-11 on Rubber and Rubber-Like Materials, and for services in his ASTM district.*

Mr. Kimmich, a native of Cleveland, Ohio, received his B.S. degree in mechanical engineering from the Case Institute of Technology. Following graduation, he was employed in the Development Department of the United States Rubber Co. In 1916 he joined the Goodyear Tire and Rubber Co. and has been associated with this organization since.

He has been associated with the ASTM since 1930 and has been active on Committees D-11 on Rubber and Rubber-Like Materials and E-1 on Methods of Testing. He has served as chairman of numerous subsections and committees associated with rubber belting, hose, and other mechanical rubber goods. He has also served on the Joint SAE-ASTM Committee on Automotive Rubber. In addition, Mr. Kimmich has been active in Cleveland District Council affairs for 15 years and served as vice-chairman.

In his work at Goodyear, he developed field splicing methods for belting which eventually led to unlimited-distance belt conveyor systems of today. He has supervised development work in hydraulic brake hose, rotary oil drilling hose, and long-length hoses for cross-country fuel distribution. He serves as editor of the Goodyear Handbook on Belting and Molded Rubber Goods.

In 1955 he attended the ISO meeting in Stockholm as American Delegate on V-belts. He has been active in numerous technical and engineering activities.

To **Bryant Mather,** *supervisory civil engineer and chief, Special Investigations Branch, Concrete Div., U. S. Army Engineer Waterways Experiment Station, Jackson, Miss., in recognition of intensive and consistent activity in ASTM technical and administrative work, especially in Committee C-9 on Concrete and Concrete Aggregates.*

Mr. Mather is supervisor of that part of the investigational work in connection with concrete and concrete materials for the Corps of Engineers in which the techniques and information of the physical sciences are employed. A native of Baltimore, Md., he was graduated from Baltimore City College in 1934, received an A.B. in geology at The Johns Hopkins University in 1936, was a graduate student in geology at The Johns Hopkins University in 1936–1938 and 1940–1941, and was a graduate student in economics at the American University in 1938–1939.

He served as assistant curator in charge of mineralogy at the Chicago Museum of Natural History from 1939 to 1941 and has been associated with concrete research for the Corps of Engineers since 1941—first as a geologist and later with the title of civil engineer.

Mr. Mather has been a member of ASTM since 1944, of Committee C-9 on Concrete and Concrete Aggregates since 1946, and of Committee C-1 on Cement since 1954. He has been chairman of Subcommittees II-b on Chemical Reactions and III-h on Admixtures of Committee C-9 and has been secretary of the committee since 1951. He is a member of the C-1 Sponsoring Committee on Blended Cements.

Besides his activities in ASTM, he is a member of the American Concrete Institute, serving on its Board of Direction, a number of its technical committees, and its Technical Activities Committee of which he was formerly chairman. He is a member of several committees of the Highway Research Board. Other memberships include the American Institute of Mining, Metallurgical, and Petroleum Engineers, the Meteoritical Society, the U. S. Committee on Large Dams, the Mississippi Geological Society, and the Mississippi Academy of Sciences. He has been author or co-author of numerous technical papers.

To **Mary R. Norton,** *metallurgist, Materials Research Laboratory, Ordnance Materials Research Office, Watertown, Mass., in recognition of constructive and consistent long-time efforts and leadership in the work of Committee E-4 on Metallography involving grain size and other standards, definitions, and editorial work.*

Miss Norton is a lifelong resident of Massachusetts. She received an A.B. in chemistry and mathematics from Emmanuel College, Boston, and an M.A. in chemistry from Columbia University, New York.

An employee of the Army Ordnance Corps for 30 years, Miss Norton has spent 25 years in the Watertown Arsenal where she has devoted her efforts to research metallography. She was assigned to her present position upon the organization of the Materials Research Laboratory of the Ordnance Materials Research Office five years ago.

Miss Norton has represented the Ordnance Corps on ASTM Committee E-4 on Metallography since 1944 and has been a personal member of ASTM since 1950. She has been secretary of Committee E-4 since 1946 and is Chairman of Subcommittee II on Definitions.

Miss Norton is the author and co-author of many publications concerned with problems in physical metallography and with production and evaluation of surface finishes. She received the U. S. War Department Meritorious Civilian Service Award for her wartime work associated with metallography and with the development of standards for ordnance finishes.

To **Lewis S. Reid** *(retired general purchasing agent, Metropolitan Life Insurance Co.) Chatham, N. J., in recognition of marked leadership and contributions to the work of committee D-6 on Paper and Paper Products, and for long constructive support of other ASTM technical and administrative work.*

Mr. Reid received from Yale University in 1919 the Bachelor of Philosophy degree in chemistry. Following graduation he returned to Yale for graduate study in chemistry 1920–1922.

Mr. Reid's professional experience has included work with the Doehler Die Casting Co. 1922–1928, and with American Cirrus Engines Co. 1928–1929 as metallurgist. From 1929 to 1932 he was chief engineer at Magnetic Analysis Corp.; 1932–1935 consulting engineer, Lucius Pitkin, Inc.; and in 1935 he joined Metropolitan Life Insurance Co. He was successively senior technician, standardization laboratory; administrative assistant to the second vice-president, coordination; assistant general purchasing agent; and general purchasing agent before his retirement in 1958.

Mr. Reid has lectured at the University of Maine and New York University and has written or edited numerous articles. He served as editor of *Aviation Engineering* magazine and consulting editor of *Metals and Alloys*.

During World War II, he served as a dollar-a-year man with the War Production Board, and later served with the General Services Administration.

Mr. Reid has been a member of ASTM since 1930. His service to the Society includes membership on Committee D-6 on Paper and Paper Products (secretary 1937–1940, chairman 1940–1948, as well as chairmanships of various of its subcommittees): D-13 on Textile Materials; D-9 on Electrical Insulating Materials; D-12 on Soaps and Other Detergents (21 years); D-21 on Wax Polishes and Related Materials; E-1 on Methods of Testing; B-2 on Non-Ferrous Metals and Alloys; and E-5 on Fire tests of Building Constructions. He has also served on the Administrative Committee on Papers and Publications, the Administrative Committee on Standards, and the New York District Council.

To **Claude K. Rice,** *coordinator, Analytical and Testing Section, Refinery Technology Laboratory, Gulf Research and Development Co., Philadelphia, Pa., in recognition of leadership and intensive effort in the work of Committee D-19 on Industrial Water and for support of other ASTM technical and administrative work.*

For 25 years, Mr. Rice has been associated with the Gulf Oil Corp. at Philadelphia. His work has dealt with problems of product quality control, sales technical service, air pollution abatement, and water examination. At present, he is a coordinator at Gulf's refinery technology laboratory in Philadelphia.

Mr. Rice represents his company on Committee D-19 on Industrial Water. He also represents the Gulf Oil Corp. in the Pennsylvania Sewage and Industrial Waste Assn. and on the Oil Refining Industry Action Committee of the Ohio River Valley Water Sanitation Commission.

He has served Committee D-19 as standards advisor since that appointive office was created. As such, he has been instrumental in standardizing a form for writing specifications and methods of test that is becoming widely recognized within ASTM and other societies.

Mr. Rice is the liaison representative of Committee D-19 on Committee D-22 on Methods of Atmospheric Sampling and Analysis and on Subcommittee 15 of Committee E-1 on Methods of Testing. He assisted in the organization of the Joint Committee on Uniformity of Methods of Water Examination on which he is an ASTM representative and of which he was the first secretary.

Mr. Rice has campaigned for cooperation among industrial and civic groups with governmental regulatory agencies in understanding and discharging responsibilities of abatement of waterborne industrial wastes.


E. G. Kimmich


Bryant Mather


M. R. Norton


L. S. Reid


C. K. Rice

Awards of Merit

To **Henry J. Schweim,** *western manager, Gypsum Assn., Hollywood, Calif., in recognition of valued and sustained participation in ASTM work, especially notable in Committee C-11 on Gypsum, and for his long-time secretarial work for this committee.*

Mr. Schweim obtained his engineering education at the Armour Institute of Technology. From 1915 until 1926 he served with the United States Gypsum Co. as sales engineer, supervisor of sales, development engineer, and district manager in various locations. From 1926 through 1947, he served as general manager of the Gypsum Assn. in Chicago. In 1947, he became western manager of the association with offices in Los Angeles.

Mr. Schweim has been active in ASTM for over 20 years. He served as secretary of ASTM Committee C-11 on Gypsum for 21 years. In addition he has been active on Committees C-12 on Mortars for Unit Masonry, E-5 on Fire Tests of Materials and Construction, and E-8 on Nomenclature and Definitions. In addition to this, he has served on several ASA sectional committees. He has also represented the Gypsum Assn. on various committees of the National Research Council, the National Fire Protection Assn., Building Officials Conference of America, and the International Conference of Building Officers. Recently Mr. Schweim was made a life member of the American Society of Civil Engineers.

H. J. Schweim

B. J. Sirois

C. K. Strobel

To **Benoit J. Sirois,** *chief metallurgist, Phelps Dodge Copper Products Corp., Bayway, N. J., in recognition of intensive and sustained activity in the work of Committee B-1 on Wires for Electrical Conductors, and for constructive support of other non-ferrous standardization and research work.*

Mr. Sirois, a native of Van Buren, Me., received the degrees of B.Ch.E and Ch.E. in 1939 and 1945, respectively, from Cooper Union. In 1931 he was employed as laboratory technician at the Phelps Dodge Copper Products Corp., Bayway, N. J., and at present holds the position of chief metallurgist with that company.

His service on ASTM committees began in 1942 when he was alternate representative for his company on Committees B-1 on Wire for Electrical Conductors and B-5 on Copper and Copper Alloys. He became a regular member of these committees the next year and has been active on their various subcommittees as well as Committees B-2 on Non-Ferrous Metals and Alloys and B-9 on Metal Powders and Metal Powder Products. Mr. Sirois was chairman of the B-5 Subcommittee on Wire and Wire Rod 1944–1950, and of the B-1 Subcommittee on Copper and Copper Alloy Conductors 1950–1959. He has also served as representative of ASTM on the ASA Sectional Committee C7 on Bare Electrical Conductors.

In addition to ASTM activities, he is a member and director of the Wire Assn. and was its vice-president 1956–1957. He has served as vice-president and chairman of the Overhead Conductor Section of the Insulated Power Cable Engineers Assn. and has represented his company on the Committee on Standards of the Copper and Brass Research Assn. (chairman 1947–1949). During wartime he participated in a Government-Industry Coordinating Committee charged with the development of watertight electrical conductors for shipboard use.

To **Charles K. Strobel,** *engineer, Consulting Department on Semiconductor Devices, Westinghouse Research Laboratories, Pittsburgh, Pa., in recognition of intensive and constructive efforts in technical activities, especially in Committee B-4 on Metallic Materials for Electrical Heating, Resistance, and Contacts, particularly notable in the work on contact materials.*

Dr. Strobel was born and educated in Pittsburgh, Pa. He received a B.S. degree in electrical engineering in 1921 from Carnegie Institute of Technology, and the M.S. and Ph.D. degrees in physics from the University of Pittsburgh.

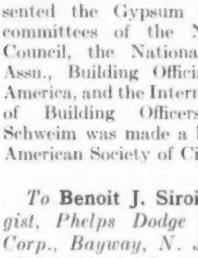
He began his industrial career as research engineer in 1921 at the Western Electric Co. in New York and continued in this type of work at the Union Switch and Signal Co., Swissvale, Pa. From 1940 to 1957 he was with the Robertshaw-Fulton Controls Co., Pittsburgh, where he served as assistant director of research and chief physicist. He left this position to join the Westinghouse Research Laboratories in Pittsburgh where he is presently employed as an engineer in the Consulting Department on Semiconductor Devices. He holds a number of industrial patents.

Dr. Strobel has been a member of ASTM since 1945 and a member of ASTM Committee B-4 on Metallic Materials for Electrical Heating, Resistance, and Contacts since 1944. He served as this committee's secretary for two years and as secretary for Subcommittee IV, Contact Materials, for 13 years. He represents B-4 on the Coordinating Committee of Committees A-1, A-9, A-10, B-2, B-4, and F-1, and on the Coordinating Committee on Non-Ferrous Metals and Alloys. He is a member for life of the American Institute of Electrical Engineers.

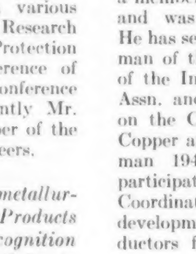
To **Herbert W. Stuart,** *director of quality control, United States Pipe and Foundry Co., Burlington, N. J., in recognition of leadership and unfailing support of numerous ASTM technical and administrative activities, especially in Committee A-3 on Cast Iron, and in his District.*

Mr. Stuart, a native of Beverly, N. J., received his degree in mechanical engineering from the Drexel Institute of Technology in 1930. Since graduation he has been employed by the United States Pipe and Foundry Co. as research engineer and has held successive positions as assistant director of research and currently director of quality control.

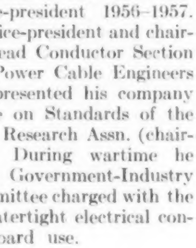
He has been active on ASTM Committee A-3 on Cast Iron and served as its secretary from 1949 to 1952 and as chairman from 1954 to 1956. In addition, he has served on Committee E-11 on Quality Control of Materials since 1957. He first became associated with ASTM in 1935 as a representative of his company. In addition to numerous sub-



H. W. Stuart



Beaumont Thomas



G. L. Werley

Fifty-Year Members Recognized at President's Luncheon

Two individual members and 12 company members received certificates of recognition as 50-year members of the Society at the President's Luncheon on Tuesday noon. Seated left to right are: J. A. Succop representing Heppenstall Co.; R. Thielking representing Schenectady Varnish Co., Inc., W. B. Tall representing Western Electric Co., Inc, Hawthorne Works; Everett W. Boughton, individual member; Joseph Brobston, individual member; Gordon Thompson representing Electrical Testing Laboratories, Inc. Standing left to right: W. R. Homan representing Commonwealth Edison Co.; C. A. Homan representing Bird and Son, Inc.; L. E MacFarlane representing Westinghouse Air Brake Co.; R. B. Corbett representing Midvale-Heppenstall Co.; and B. J. Sirois representing Phelps Dodge Copper Corp. Fifty-year member representatives not in the photograph are K. K. Kirwan, Raymond Concrete Pile Co., M. Van Loo, Sherwin-Williams Co., and John K. Mayer, Tulane University of Louisiana.

committee posts, he represents Committee A-3 on the Advisory Committee on Corrosion. He is a member of the ASTM Philadelphia District Council, serving as vice-chairman.

Mr. Stuart has been actively engaged in the technical committee activities of the Cast Iron Pipe Research Assn. and serves as one of its representatives to ASA Sectional Committee A-21 on Cast Iron Pressure Pipe. He is vice-chairman of this group. He assisted in the organization of the American group that is actively participating in the ISO Technical Committee 25 on Cast Iron, and led the first delegation to London in 1955.

To **Beaumont Thomas,** *director and vice-president for development and research, The Stebbins Engineering and Manufacturing Co., Watertown, N. Y., in recognition of faithful and constructive leadership in all of the technical work of Committee C-3 on Chemical-Resistant Mortars, and for administrative support as secretary and chairman of this committee.*

Mr. Thomas was born in South Wales, Great Britain, and became a citizen of the United States in 1933. Since 1952, he has been vice-president for development and research of The Stebbins Engineering and Manufacturing Co. and recently was elected a director of this company. He holds a Bachelor's degree with a major in chemistry from West Virginia University.

Following graduation, he served as a chemist with the Weirton Steel Co. until 1937 when he joined the Battelle Memorial Institute as a research engineer. In 1939, he joined The Stebbins Engineering and Manufacturing Co. as chief chemist, and in 1952 was elected to his present position.

Mr. Thomas is a charter member of ASTM Committee C-3 on Chemical-Resistant Mortars. He has served as chairman of this committee for six years and as secretary for four. He is also a member of ASTM Committee C-15 on Manufactured Masonry Units.

In addition to his membership in ASTM, Mr. Thomas is a member of the American Chemical Society, the American Institute of Chemists, the Technical Association of the Pulp and Paper Industry, and the National Association of Corrosion Engineers. He is the author of numerous technical publications and is a member of Phi Beta Kappa and Phi Lambda Upsilon.

To **George L. Werley,** *research investigator, The New Jersey Zinc Co., Palmerton, Pa., in recognition of outstanding service and technical and administrative leadership, especially in the field of die castings, specifically in Committee B-6 on Die Cast Metals and Alloys, and his long service as secretary of this committee.*

Mr. Werley is a native of New [illegible]i, Pa. He was educated at The Pennsylvania State University where he received the degree of B.S. in chemical engineering. After graduation he joined The New Jersey Zinc Co. and has remained there ever since with the exception of a few months in 1942 when he was loaned to the War Production Board.

He is co-holder of four patents on zinc-base die-casting alloys, has contributed sections to the ASM Handbook and Kent's Engineering Handbook, and is the author of a number of papers and magazine articles on zinc alloy die casting and brass powder metallurgy.

Mr. Werley has been active in the work of ASTM Committee B-6 on Die-Cast Metals and Alloys and has been the committee's secretary since 1938. He has represented Committee B-6 on Committee B-7 on Light Metals and Alloys, on Committee E-1 on Methods of Testing, and on the Coordinating Committee on Non-Ferrous Metals and Alloys. He is also a member of Committee B-9 on Metal Powders and Metal Powder Products.

Mr. Werley is a member of the Metal Powder Assn. He was technical director for an industrial movie on zinc and die casting for the American Zinc Institute and the American Die Casting Institute. He is also a member of the Palmerton Board of Trade and Phi Lambda Upsilon

Forty-Year Members Recognized at President's Luncheon

Forty-year members of the Society who were at the President's Luncheon to receive certificates are shown in the photograph. Standing left to right: C. L. Guettel representing Driver-Harris Co.; P. V. Reader representing The National Supply Co., Subsidiary of Armco Steel Corp.; C. W. Wheatley representing A. O. Smith Corp.; W. S. Weaver, representing Canada Cement Co., Ltd.; V. B. Smesrude representing Union Pacific Railroad Co.; R. W. Seniff representing The Baltimore & Ohio Railroad Co.; V. R. Weathers representing the Kansas State Highway Commission; G. D. Patterson, Sr., representing E. I. du Pont de Nemours & Co., Inc. Seated left to right: J. W. Gunn representing Lone Star Cement Co.; individual members C. H. Marshall, F. M. Howell, E. E. Eakins, Robert D. Bonney, W. M. Weil, and Ray T. Bayless; W. M. Barnum representing Northern States Power Company.

Medals and Awards

Research in Engineering Materials


R. J. MacDonald


R. L. Carlson


W. T. Lankford

CHARLES B. DUDLEY MEDAL

This medal was established by voluntary subscriptions from the members as a means of stimulating research in materials and of recognizing meritorious contributions to its publications, at the same time commemorating the first president of the Society, whose inspiring leadership has had a profound influence on its development.

● 1959 award to **Robert J. MacDonald, R. L. Carlson,** and **W. T. Lankford** for their paper, "The Effects of Strain Rate and Temperature on the Stress-Strain Relations of Deep-Drawing Steel," presented at the 1956 Annual Meeting of the Society.

Robert J. MacDonald is head of the Bearing and Friction Materials Section of the Mechanical Research Division, Clevite Research Center, Cleveland, Ohio. He received his B.A. degree in chemistry and physics from Hiram College and his B.S. degree in metallurgical engineering from Carnegie Institute of Technology. After graduation he joined the Gas Turbine Division of General Electric Co., where he was engaged in research on high-temperature materials. In 1952 he became associated with Battelle Memorial Institute as a principal metallurgist in the Mechanical Metallurgy Division. In 1956 he joined the Clevite Corp. as a senior metallurgist and in 1958 was appointed to his present position, where he is concerned with development, testing, and evaluation of rubbing-contact material. Mr. MacDonald is a member of ASM, AIME, and ASIE.

R. L. Carlson, Battelle Memorial Institute, Columbus, Ohio, is a native of Gary, Ind. After service in the army, he attended Purdue University and received a B.S. in mechanical engineering. Following graduation, he became an instructor and graduate student in the Department of Engineering Mechanics at Purdue and received his M.S. in engineering mechanics in 1950. Mr. Carlson joined the staff of Battelle Memorial Institute as a research engineer and since 1954 has been assistant division chief concerned with research on the mechanical behavior of engineering materials. He is a member of Pi Tau Sigma and Tau Beta Pi.

W. T. Lankford, chief research engineer, specialty products, United States Steel Corp., Monroeville, Pa., was educated at Carnegie Institute of Technology, where he received a B.S. in metallurgical engineering in 1941 and a D.Sc. in metallurgical engineering in 1945. He was employed as a research metallurgist at Carnegie Institute of Technology and at The Pennsylvania State University. In 1945 he joined United States Steel Corp.

Mr. Lankford, a member of ASTM, serves on Committee E-9 on Fatigue and on the Administrative Committee on Papers and Publications. In 1949 he received the Society's Richard L. Templin Award. He is also a member of ASME, AIME, ASM, and the Society for Experimental Stress Analysis.

Industrial Water


L. D. Betz

MAX HECHT AWARD

This award, in honor of the first chairman of Committee D-19 on Industrial Water, is presented to a member of that committee in recognition of outstanding service to the committee in the advancement of its objective—the study of water as an engineering material.

● 1959 award to **L. D. Betz.**

L. Drew Betz, president and director of Betz Laboratories, was managing director of the firm of W. H. & L. D. Betz from the time he and his father organized it in 1925. He became president and director when the firm was reorganized in 1957 as Betz Laboratories.

A native of Philadelphia, Mr. Betz was graduated in chemistry from Drexel Institute of Technology in 1914, after which he took an extra year in organic chemistry. From 1914 to 1917 he was a chemist with the Animal Oil Co., Philadelphia, and from 1917 to 1925 chemist and later vice-president of E. F. Drew & Co., Inc., Philadelphia, New York, and Boston.

Mr. Betz has been a member of ASTM since 1937. He has been a member of Committee D-19 on Industrial Water since 1942 and has represented D-19 on the Standards Methods Committee of the American Public Health Assn. He also represented D-19 on the former Joint Committee on Boiler Feedwater studies and is currently vice-chairman of the ASME research committee which replaced it. In addition, he represented Committee D-19 on the Federation of Sewage Works Associations Standards Methods Committee.

A member of the Philadelphia District Council, he has served as both secretary and vice-chairman. In 1956 he received the Society's Award of Merit for valued contributions in various ASTM areas, notably the field of industrial water and in District activities.

Mr. Betz is also an active member of The American Society of Mechanical Engineers, American Chemical Society, and American Water Works Assn. He has written several articles and papers on various water-conditioning processes and problems.

Testing of Soils


W. E. Schmid

C. A. HOGENTOGLER AWARD

This award was established by Committee D-18 on Soils to commemorate its first chairman, to be given to authors of outstanding papers on soils presented at a meeting of the Society.

● 1959 award to **Werner E. Schmid** for his paper, "The Permeability of Soils and the Concept of a Stationary

Boundary Layer," presented at the 1957 Annual Meeting of the Society.

Werner E. Schmid, associate professor of civil engineering, Princeton University, is a native of Munich, Germany. He studied at the Technische Hochschule in Munich, where he was granted the degree of Diplom Ingenieur in 1953, and later became associated with the Bavarian Power and Light Co. as a designer. A Fulbright Fellowship Award brought him to the United States where he received a Master's degree from Lehigh University. He joined the faculty of Lafayette College as an instructor and in 1956 was appointed assistant professor at Princeton University.

Professor Schmid is actively engaged in research for the Office of Naval Research. He has been a consultant on several projects including the St. Lawrence Seaway and is author or co-author of several papers on water movement in soils, lateral earth pressures, and stress measurement. He has been a member of ASTM since 1955 and serves on Committee C-18 on Soils for Engineering Purposes.

Corrosion Research and Tests

J. B. Rittenhouse

SAM TOUR AWARD

The purpose of this award is to encourage research on the improvement and evaluation of corrosion testing methods and to stimulate the preparation of technical papers in this field.

● 1959 award to **John B. Rittenhouse** for his paper, "The Corrosion and Ignition of Titanium in Fuming Nitric Acid," presented at the Second Pacific Area National Meeting of the Society in 1956.

John B. Rittenhouse, Jet Propulsion Laboratory, California Institute of Technology, was born in Milwaukee, Wis., and received his education at the University of Wisconsin and Marquette University. He holds the degrees of B.Ch.E and M.S. from Marquette.

He was engaged in inspection, supervision, and research at the Steel Foundry of the Falk Corp.; was assistant professor of mechanical engineering at Marquette University and consultant on X-ray diffraction and special metallurgical Problems of the Ladish Co. He was also chief metallurgist at Ampco Metal Inc., Milwaukee.

Since moving to California in 1955, Mr. Rittenhouse has been X-ray consultant and applications engineer at Applied Research Laboratories in Glendale and was research group supervisor in the Chemistry Section at the Jet Propulsion Laboratory. He is currently research specialist in the Materials Section at the Jet Propulsion Laboratory and is working on the properties of materials at very high temperatures.

He is a member of the American Society for Metals, Society for Nondestructive Testing (secretary-treasurer 1953), and the American Foundrymen's Society.

Test Methods and Apparatus

J. H. Westbrook

RICHARD L. TEMPLIN AWARD

The purpose of this award is to stimulate research in the development of testing methods and apparatus, to encourage the presentation to the Society of papers describing new and useful testing procedures and apparatus, and to recognize meritorious efforts of this kind.

● 1959 award to **J. H. Westbrook** for his paper, "Microhardness Testing at High Temperature," presented at the Second Pacific Area National Meeting of the Society in 1956.

J. H. Westbrook, metallurgist, General Electric Research Laboratory, Schenectady, N. Y., is a resident of Ballston Spa, N. Y. and a graduate of Rensselaer Polytechnic Institute, from which he received his Bachelor's and Master's degrees in metallurgical engineering. In 1949 he received the degree of Sc.D. from Massachusetts Institute of Technology; he joined the General Electric Co. in that same year.

Dr. Westbrook is a licensed professional engineer, State of New York. He is a member of ASM, AIME, American Ceramic Society, Electrochemical Society (presently vice-chairman of the Electrothermics & Metallurgy Division), British Institute of Metals, and the Materials advisory Board, National Academy of Science. In 1957 he was the recipient of the Francis Mills Turner Award of the Electrochemical Society and in 1959 the Alfred H. Geisler Award of the Eastern New York Chapter, ASM. He is a member of Sigma Xi, Tau Beta Pi, and Phi Lambda Upsilon. He is also the author of numerous technical papers on the structure and properties of metals and ceramics.

Concrete and Its Aggregates

George Verbeck

SANFORD E. THOMPSON AWARD

This award was established by Committee C-9 on Concrete and Concrete Aggregates to commemorate its first chairman, to be given to authors of papers of outstanding merit in that field, to stimulate research and extension of knowledge, and to recognize meritorious efforts.

● 1959 award to **George Verbeck** for his paper, "Carbonation of Hydrated Portland Cement," presented at the Second Pacific Area National Meeting of the Society in 1956.

George Verbeck is manager, Applied Research Section, Portland Cement Assn. He is a graduate of Lawrence College (B.A. in chemistry) and the University of Chicago (S.M. in physical chemistry). He joined the Portland Cement Assn. in 1941 and was subsequently employed by The Institute of Gas Technology and Koppers Co., Inc., Butadiene Division. He rejoined the PCA in 1945.

His researches concerning numerous aspects of cement and concrete technology have been published by ASTM, the Highway Research Board, and the American Concrete Institute. He is a member of ASTM Committees C-1 on Cement and C-9 on Concrete and Concrete Aggregates, representing the Portland Cement Assn. Mr. Verbeck is also a member of ACI and the American Chemical Society.

New Tentatives and Standards

Technical Committees Keep Pace with Changing Technology

At the 62nd Annual Meeting the Society accepted 92 new tentative specifications and methods of test, the titles and designations of which are given below. Other actions taken at the meeting in regard to standards are summarized in the box.

The numerical designations of the technical committees responsible for these tentatives are shown after the boldface headings.

STEEL (A-1)

Method and Specification for:

Ultrasonic Testing and Inspection of Steel Plates of Firebox and Higher Quality (A 435 – 59 T)

Specifications for:

Deformed Billet Steel Bars for Concrete Reinforcement with 60,000 psi Minimum Yield Point (A 432 – 59 T)

Leaded Carbon Steel Plates of Flange and Firebox Qualities for Fusion Welded Boilers and Other Pressure Vessels (A 433 – 59 T)

Quenched and Tempered Alloy Steel Bars, Hot-Rolled or Cold-Finished (A 434 – 59 T)

CAST IRON (A-3)

Specification for:

Austenitic Gray Iron Castings (A 436 – 59 T)

WIRES FOR ELECTRICAL CONDUCTORS (B-1)

Method of Test for:

Eddy Current Method for Determination of Electrical Conductivity (B 342 – 59 T)

Specification for:

Aluminum-Coated (Aluminized) Steel Core Wire for Aluminum Conductors, Steel Reinforced (ACSR) (B 341 – 59 T)

METALLIC MATERIALS FOR ELECTRICAL HEATING, ELECTRICAL RESISTANCE, AND ELECTRICAL CONTACTS (B-4)

Specifications for:

Drawn or Rolled Nickel-Chromium and Nickel-Chromium-Iron Alloys for Electrical Heating Elements (B 344 – 59)

Method of:

Accelerated Life Test of Iron-Chromium-Aluminum Alloys for Electrical Heating (B 343 – 59 T)

LIGHT METALS AND ALLOYS, CAST AND WROUGHT (B-7)

Specification for:

Aluminum Alloy Pipe for Gas and Oil Transmission and Distribution Piping Systems (B 345 – 59 T)

METAL POWDERS AND METAL POWDER PRODUCTS (B-9)

Method for:

Hardness of Sintered Metal Friction Materials (B 347 – 59 T)

Specifications for:

Machinable High-Density Tungsten-Nickel-Copper Alloys (B 346 – 59 T)

CEMENT (C-1)

Method of Test for:

Fineness of Hydraulic Cement by the No. 325 Sieve (C 430 – 59 T)

CHEMICAL-RESISTANT MORTARS (C-3)

Method of Test for:

Chemical Resistance of Mortars (C 341 – 59 T)

LIME (C-7)

Specifications for:

Quicklime and Hydrated Lime for Hypochlorite Bleach Manufacture (C 433 – 59 T)

Pozzolans for Use with Lime (C 432 – 59 T)

REFRACTORIES (C-8)

Methods of Test for:

Size and Bulk Density of Insulating Fire Brick (C 437 – 59 T)

Reheat Change of Carbon Brick and Shapes (C 436 – 59 T)

Thermal Conductivity of Plastic Refractories (C 438 – 59 T)

Resistance to Thermal Spalling of Silica Brick (C 439 – 59 T)

Specifications for:

Steel Pouring Pit Refractories (C 435 – 59 T)

Insulating Fire Brick for Linings of Industrial Furnaces Operated with a Neutral or Oxidizing Atmosphere (C 434 – 59 T)

CONCRETE AND CONCRETE AGGREGATES (C-9)

Method of Test for:

Effectiveness of Mineral Admixtures in Preventing Excessive Expansion of Concrete Due to the Alkali-Aggregate Reaction (C 441 – 59 T)

Specifications for:

Cotton Mats for Curing Concrete (C 440 – 59 T)

GYPSUM (C-11)

Specifications for:

Gypsum Backing Board (C 442 – 59 T)

CONCRETE PIPE (C-13)

Specifications for:

Joints for Circular Concrete Sewer and Culvert Pipe, Using Flexible, Watertight, Rubber-Type Gaskets (C 443 – 59 T)

Perforated Concrete Pipe (C 444 – 59 T)

SUMMARY OF ACTIONS TAKEN AT 1959 ANNUAL MEETING AFFECTING STANDARDS AND TENTATIVES.

	New Standards and Existing Tentatives Adopted as Standard	Standards in Which Revisions Will Be Adopted	New Tentatives	Revisions of Standard and Reversions to Tentative	Tentative Revisions of Standards	Tentatives Revised	Standards and Tentatives Withdrawn
A. Ferrous Metals—Steel, Cast Iron, Wrought Iron, Alloys, etc.	6	14	5	1	1	32	3
B. Non-Ferrous Metals—Copper, Zinc, Lead, Aluminum, Alloys, etc.	8	24	6	...	2	19	2
C. Cement, Lime, Gypsum, Concrete and Clay Products	5	22	19	5	4	16	2
D. Paints, Petroleum Products, Bituminous Materials, Paper, Textiles Plastics, Rubber, Soap, Water, etc.	53	41	53	8	6	54	7
E. Miscellaneous Subjects, Testing, etc.	...	1	5	...	2	10	...
F. Electronic Materials	...	2	1	...	...	...	2
Total	72	104	89	14	15	131	16

THERMAL INSULATING MATERIALS (C-16)

Method of Test for:

Normal Total Emittance of Surfaces of Materials 0.01 In. or Less in Thickness at Approximately Room Temperature (C 445 – 59 T)

Breaking Strength and Calculated Modulus of Rupture of Preformed Insulation for Pipes (C 446 – 59 T)

Method for:

Determining the Maximum Use Temperature of Preformed High-Temperature Insulation (C 447 – 59 T)

PORCELAIN ENAMEL (C-22)

Methods of Test for:

Abrasion Resistance of Porcelain Enamels (C 448 – 59 T)

PAINT, VARNISH, LACQUER, AND RELATED PRODUCTS (D-1)

Specifications for:

Strontium Chromate (D 1649 – 59 T)

Basic Lead Silico-Chromate (D 1648 – 59 T)

Method of Test for:

Phthalic Acid Isomers and Benzoic Acid in Alkyd Resins and Esters (D 1651 – 59 T)

Epoxy Content of Epoxy Resins (D 1652 – 59 T)

Moisture Vapor Permeability of Organic Coating Films (D 1653 – 59 T)

Method for:

Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments (D 1654 – 59 T)

Sampling and Testing Shellac Varnish (D 1650 – 59 T)

PETROLEUM PRODUCTS AND LUBRICANTS (D-2)

Methods of Test for:

Maximum Fluidity Temperature of Residual Fuel Oils (D 1659 – 59 T)

Thermal Stability of Aviation Turbine Fuels (D 1660 – 59 T)

Knock Characteristics of Motor Fuels Above 100 Octane Number by the Research Method (D 1656 – 59 T)

Specific Gravity of Light Hydrocarbons by Pressure Hydrometer (D 1657 – 59 T)

Carbon Number Distribution of Aromatic Compounds in Naphthas by Mass Spectrometry (D 1658 – 59 T)

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Specifications for:

Aviation Turbine Fuels (D 1655– 59 T)

ROAD AND PAVING MATERIALS (D-4)

Methods of Test for:

Engler Specific Viscosity of Tar Products (D 1665 – 59 T)

Coating and Stripping of Bitumen-Aggregate Mixtures (D 1664 – 59 T)

Penetration of Bituminous Materials (D 5 – 59 T)

Specifications for:

Hot-Mixed, Hot-Laid Asphalt Paving Mixtures (D 1663 – 59 T)

WOOD (D-7)

Methods of:

Conducting Machining Tests of Wood and Wood-Base Materials (D 1666 – 59 T)

ELECTRICAL INSULATING MATERIALS (D-9)

Methods of Test for:

Gamma Radiation by Chemical Dosimetry (Jointly with D-20) (D 1671 – 59 T)

(*Continued on page 52*)

62nd Annual Meeting

YOUR HOSTS....

AT THE 62nd Annual Meeting were the members of the Philadelphia District Council. As they have so often in the past, these capable men played an important part in the meeting arrangements.

Chairman of the District is Allen H. Kidder, Philadelphia Electric Co.; dinner chairman was E. J. Albert, Thwing-Albert Instrument Co.; entertainment, E. K. Spring, Pencoyd Steel and Forge Corp.; and ladies entertainment, L. Drew Betz, Betz Laboratories, and James J. Moran, Kimble Glass Co.

Forty- and Fifty-Year Members

The Society gave recognition at the Annual Meeting to many of its long-term members by presenting them with 40-year and 50-year membership certificates.

50-YEAR MEMBERS

Everett W. Boughton
Joseph Brobston
Bird and Son, Inc.
Commonwealth Edison Co.
Electrical Testing Laboratories, Inc.
Heppenstall Co.
Midvale-Heppenstall Co.
Phelps Dodge Copper Products Corp.
Raymond Concrete Pile Co.
Schenectady Varnish Co., Inc.
The Sherwin-Williams Co.
Tulane University of Louisiana
Western Electric Co., Inc., Hawthorne Works
Westinghouse Air Brake Co.

40-YEAR MEMBERS

Individual Members

Ray T. Bayless
Robert D. Bonney
W. H. Campen
T. G. Delbridge
Edgar Hutton Dix, Jr.
E. E. Eakins
Max Herzog
Francis M. Howell
Charles H. Marshall
F. R. McMillan
Nathan C. Rockwood
Stephen F. Voorhees
Walter M. Weil
Guy M. Williams

Other Members

Arizona State Highway Department
The Baltimore & Ohio Railroad Co.
Canada Cement Co., Ltd.
The Chesapeake & Ohio Railway Co.
City and Guilds College Library
The Colorado Fuel and Iron Corp., Wickwire Spencer Steel Division, Claymont Plant
Columbia-Geneva Steel Div., U. S. Steel Corp.
Driver-Harris Co.
E. I. du Pont de Nemours and Co., Inc.
Erie Railroad Co.
Georgia Institute of Technology Library
Georgia State Highway Department
Kansas State Highway Commission
Kellogg Switchboard and Supply Co.
Lone Star Cement Corp.
Montana State Highway Dept.
New York Central System
New York, New Haven & Hartford Railroad Co.
Northern States Power Co.
Phoenix Bridge Co.
Lucius Pitkin, Inc.
City of Rochester, Department of Public Works, Division of Engineering
St. Joseph Lead Co.
The Shawinigan Engineering Co., Ltd.
The Singer Manufacturing Co.
A. O. Smith Corp.
The National Supply Co., Subsidiary of Armco Steel Corp.
Union Pacific Railroad Co.
R. T. Vanderbilt Co., Inc.
Wellington Sears Co., Inc.
West Coast Lumbermen's Assn.

New Tentatives and Standards

Technical Committees Keep Pace with Changing Technology

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Midvale-Heppenstall Co.
Phelps Dodge Copper Products Corp.
Raymond Concrete Pile Co.
Schenectady Varnish Co., Inc.
The Sherwin-Williams Co.
Tulane University of Louisiana
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Westinghouse Air Brake Co.

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E. E. Eakins
Max Herzog
Francis M. Howell
Charles H. Marshall
F. R. McMillan
Nathan C. Rockwood
Stephen F. Voorhees
Walter M. Weil
Guy M. Williams

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Canada Cement Co., Ltd.
The Chesapeake & Ohio Railway Co.
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Driver-Harris Co.
E. I. du Pont de Nemours and Co., Inc.
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Kellogg Switchboard and Supply Co.
Lone Star Cement Corp.
Montana State Highway Dept.
New York Central System
New York, New Haven & Hartford Railroad Co.
Northern States Power Co.
Phoenix Bridge Co.
Lucius Pitkin, Inc.
City of Rochester, Department of Public Works, Division of Engineering
St. Joseph Lead Co.
The Shawinigan Engineering Co., Ltd.
The Singer Manufacturing Co.
A. O. Smith Corp.
The National Supply Co., Subsidiary of Armco Steel Corp.
Union Pacific Railroad Co.
R. T. Vanderbilt Co., Inc.
Wellington Sears Co., Inc.
West Coast Lumbermen's Assn.

Provisional Program — Third

San Francisco, Calif. Oct. 12–16, 1959

This program is subject to change

This program with fifty-three separate sessions including upwards of 225 technical papers, is the most extensive ever sponsored by ASTM. It bespeaks the tremendous interest in materials, their properties and evaluation, and it also is a credit to the intensive efforts of the various symposium chairmen, the technical committees which are sponsoring many sessions and the authors. The program has been developed under the guidance of the Pacific Area Program Committee and the Administrative Committee on Papers and Publications.

	MONDAY, Oct. 12	TUESDAY, Oct. 13	WEDNESDAY, Oct. 14	THURSDAY, Oct. 15	FRIDAY, Oct. 16
MORNING	**Session on Paint** **Symposium on Masonry Materials** **Symposium on Ceramics in Nuclear Energy** (Cont.) **Symposium on Non-destructive Testing in the Missile Industry** (Cont.) **Symposium on Spectroscopy** (Cont.) Committee Meetings	**Symposium on Applied Radiation and Radioisotope Test Methods** (Cont.) **Symposium on Durability and Weathering of Structural Sandwich Constructions** (Cont.) **Symposium on Hydraulic Fluids** (Cont.) **Symposium on Spectroscopy** (Cont.) **Symposium on Materials in the Electronics Industry** Committee Meetings	**Symposium on Effect of Water-Reducing and Set-Retarding Admixtures on Properties of Concrete** (Cont.) **Symposium on Radiation Effects and Dosimetry** (Cont.) **Symposium on Wood in Building Construction** (Cont.) **Symposium on Fatigue of Aircraft Structures** (Cont.) **Symposium on Reinforced Plastics** (Cont.) Committee Meetings	**Symposium on Radiation Effects and Dosimetry** (Concl.) **Symposium on Road and Paving Materials** (Cont.) **Symposium on Fatigue of Aircraft Structures** (Concl.) **Symposium on Spectroscopy** (Cont.) **Symposium on Thermal Ablation** (Cont.) **Symposium on Technical Development in the Handling and Utilization of Water and Industrial Waste Water** (Cont.) Committee Meetings	**Symposium on Bituminous Waterproofing and Roofing Materials** (Cont.) **Symposium on Soils for Engineering Purposes** (Cont.) **Symposium on Newer Metals** (Cont.) **Symposium on Air Pollution Control** (Cont.) **Symposium on Post Irradiation Effects in Polymers** Committee Meetings
LUNCHEONS	**Statistical Luncheon**	**Petroleum and Chemical Industry Luncheon** **Electronics Industry Luncheon**	**President's National Luncheon**	**Industrial Water Industry Luncheon** **Cement and Concrete Industry Luncheon**	
AFTERNOON	**Symposium on Methods for Testing Building Constructions** **Symposium on Ceramics in Nuclear Energy** (Concl.) **Symposium on Non-destructive Testing in the Missile Industry** (Concl.) **Symposium on Electrical Insulating Materials** **Symposium on Spectroscopy** (Cont.) Committee Meetings	**Symposium on Applied Radiation and Radio-isotope Test Methods** (Concl.) **Symposium on Durability and Weathering of Structural Sandwich Constructions** (Concl.) **Symposium on Hydraulic Fluids** (Concl.) **Symposium on Spectroscopy** (Cont.) **Symposium on Treated Wood for Marine Use** **Nuclear Problems Forum** Committee Meetings	**Symposium on Effect of Water-Reducing and Set-Retarding Admixtures on Properties of Concrete** (Concl.) **Symposium on Radiation Effects and Dosimetry** (Cont.) **Symposium on Wood in Building Construction** (Concl.) **Symposium on Fatigue of Aircraft Structures** (Cont.) **Symposium on Reinforced Plastics** (Concl.) Committee Meetings	**Symposium on Road and Paving Materials** (Concl.) **Symposium on Newer Metals** (Cont.) **Symposium on Spectroscopy** (Concl.) **Symposium on Thermal Ablation** (Concl.) **Symposium on Technical Development in the Handling and Utilization of Water and Industrial Waste Water** (Concl.) **Symposium on Adhesion and Adhesives** Committee Meetings	**Symposium on Bituminous Waterproofing and Roofing Materials** (Concl.) **Symposium on Soils for Engineering Purposes** (Concl.) **Symposium on Newer Metals** (Concl.) **Symposium on Air Pollution Control** (Concl.) **Symposium on Standards — Are Changes in Order?** Committee Meetings

Pacific Area National Meeting

PROGRAM CHANGES

THE TECHNICAL PROGRAM for the San Francisco meeting remains practically unchanged from that published in the preliminary program mailed to members the beginning of June and shown on the opposite page. The Symposium on Adhesion and Adhesives is outlined below, since this information was not available for inclusion in the preliminary program. Other changes are also listed. It should also be noted that the morning sessions will start at 8:30 rather than 9 o'clock and the afternoon sessions will start at 2:30 rather than 2:15 p.m.

Symposium on Adhesion and Adhesives Thursday, October 15, 2:30 p.m.

Surface Chemistry of Adhesion—Samuel Muchnick, consultant.

Lap Shear and Creep Testing in Germany—K. F. Hahn, Douglas Aircraft Co.

Elevated Temperature Resistant Metal-to-Metal Adhesives Derived from Organic-Inorganic Polymer Systems—E. C. Janis, Narmco Industries, Inc.

Preliminary Evaluation of Ceramic Adhesives for Stainless Steel—L. E. Gates and W. E. Lent, Hughes Aircraft Co.

Symposium on Effect of Water-Reducing and Set-Retarding Admixtures on Properties of Concrete, Wednesday, Oct. 14

The following two papers will be in the morning session rather than the afternoon session:

Improved Concrete with Water-Reducing, Cement Dispersing, Retarding Admixtures—G. W. Wallace and E. L. Ore, U. S. Bureau of Reclamation.

Properties of Concretes Containing Water-Reducers and Retarders as Influenced by Portland Cement Composition—Milos Polivka and Alexander Klein, University of California.

The following two papers will be in the afternoon session rather than the morning session:

Introduction to Producers' Papers on Water-Reducing Admixtures and Retarding Admixtures: Classification, Mechanism, and Product Control—M. R. Prior and A. B. Adams, Dewey and Almy Chemical Co.

Effect of Water-Reducers and Retarders on the Properties of Plastic Concrete—C. A. Vollick, Sika Chemical Corp.

Symposium on Radiation Effects and Dosimetry, Wednesday, October 14 and Thursday, October 15.

The following paper has been added to the Wednesday morning session:

Removal Dose as an Environmental Measurement of X-Rays and Gamma Rays—R. L. Hickmott, Wright Air Development Center.

The papers by Messrs. Uthe and Kircher, and Bartz and Ronsick have been withdrawn from the Thursday morning session and the following two papers added:

Standardizatian of Terminology for Gamma and Electron Beam Radiation Sources—G. E. Danald, Quartermaster Food and Container Institute for the Armed Forces.

Neutron Radiation Embrittlement at 500 F of Pressure Vessel Steel—H. F. Alger and L. M. Skupien, Westinghouse Electric Corp.

Symposium on Applied Radiation and Radioisotope Test Methods, Tuesday, October 13

The title of the paper by A. A. Schultz of General Electric Co. has been changed to *Grain Boundary Segregation Studies by Activation.*

Symposium on Nondestructive Testing in the Missile Industry, Monday Oct. 12

The title of the paper by Herbert Kraus of North American Aviation, Inc., has been changed to *Ultrasonic Inspection of Metal Bonds.*

Symposium on Wood in Building Construction, Wednesday, October 14.

The paper by Mr. W. H. O'Brien of Southern Pine Assn. has been withdrawn.

Symposium on Spectroscopy, Monday, October 12, Tuesday, October 13, Thursday, October 15

Since additional material has been added and some of the titles of the papers have been changed, this program is listed below in its entirety.

Monday, October 12, 8:30 a.m.—Mainly Optical Emmission

Introductory Remarks—R. E. Hess, American Society for Testing Materials

Challenges in Atomic Spectroscopy—J. R. McNally, Jr., Oak Ridge National Laboratory.

Spectroscopy of Radioactive Materials—John Conway, Lawrence Radiation Laboratory, University of California

Communications in Spectrochemical Analysis—David Fry, General Motors Laboratory

Monday, October 12, 2:30 p.m.—X-Ray and Spectroscopy

The Future of X-Ray Fluorescence Instrumentation—J. W. Kemp, Applied Research Laboratory.

Application of X-Ray Spectroscopy to Unsolved Problems in Geochemistry—Isidore Adler, U. S. Geological Survey.

Quantitative Light Element Analysis, Fe to Mg, for Portland Cement by X-Ray Spectroscopy—E. A. Curley, Riverside Cement Co.

Basic Practices in X-Ray Fluorescence—L. S. Birks, U. S. Naval Research Laboratory

Tuesday, October 13, 8:30 a.m.—Ultraviolet Absorption and Flame Photometry

Spectroscopy in the Region 175–200mμ—Wilbur Kaye, Beckman Instruments, Inc.

Selected Topics in Flame Photometry—Bert Vallee, Harvard Medical School.

Analytical Flame Photometry: New Developments—Paul Gilbert, Beckman Instruments, Inc.

Tuesday, October 13, 2:30 p.m.—Magnetic Resonance

Nuclear Magnetic Resonance (NMR) Spectroscopy—J. N. Shoolery, Varian Assoc.

The Unpaired Electron via EPR—R. H. Sands, University of Michigan.

Maser Applications and Traveling-Wave Techniques for Magnetic Resonance Spectroscopy—A. E. Siegman, Stanford University.

(Continued on page 51)

ARDC Commander to Speak at West Coast Luncheon

Lieutenant General Bernard A. Schriever, Commander, Air Research and Development Command, U. S. Air Force, will be guest of honor and speaker at the President's Luncheon during the Third Pacific Area National Meeting in San Francisco on Wednesday, Oct. 14.

General Schriever established the Missile Division of the Air Force Research and Development Command in Los Angeles and was recently made Commander of ARDC. A distinguished Air Force leader both in combat and in engineering and science, he has spearheaded much of the Air Force work in missiles.

ASTM Bulletin

No. 239 July 1959

Nineteen-Sixteen
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Philadelphia 3, Penna.

Second Hip Operation for Executive Secretary Painter

EXECUTIVE SECRETARY R. J. Painter entered Chestnut Hill Hospital on Tuesday, June 30, and on July 3 underwent a second operation—this time on his right hip. Following the procedure used in March, 1958, on the left side, a Vitallium prosthesis was inserted and as this BULLETIN goes to press satisfactory progress was reported. Osteoarthritis caused deterioration of the lining in the hip joints, but the basic reasons for this have not been discovered.

The latest practice in situations of this kind is to use a Vitallium precision casting (these come in different sizes) which is snugly fitted into the thigh bone and into the hip bone socket. Nature then repairs the muscles and builds around the casting and in time much of the discomfort disappears although there may be some restriction in the movement of the legs.

The Executive Secretary regrets that his days of tennis, baseball playing, and related activities are over but is grateful that the metallurgist, in collaboration with medical science, has given us material that provides such great relief in cases of this kind.

Following about a month in Chestnut Hill Hospital, Mr. Painter expects again to go to All Saints Episcopal Hospital in Chestnut Hill for a month or six weeks of physical therapy and further convalescence. He anticipates he will be handling correspondence, reading, etc., during much of the hospital stay and fully expects to get to the West Coast Meeting the week of October 11 in San Francisco.

Education and ASTM

THE INTEREST of the ASTM in education is emphasized by the prominent part played by the Symposium on Education, sponsored jointly with the American Society for Engineering Education, in the Annual Meeting program. Sponsorship of this highly stimulating symposium pointed up the concern of the Society with formal education in general and with questions of curricula in particular. To this should be added the fact that the Society has sponsored projects over the years at various schools and has supported scholarships, an activity that is now being stepped up with the underwriting of fellowships and other types of assistance.

ASTM and Education are no strangers. The Society itself is recognized as an educational and scientific institution. And well it might be. Not only were its early beginnings closely associated with the academic field, but its very statement of purpose includes "the promotion of knowledge of engineering materials." Many of our publications are directed to this end. Many developments in materials trace their origins to a basic paper presented before the Society. And who can say how much the discussions in committee meetings have contributed to the post-graduate education of the participants?

The educational contributions of the Society are many. The spotlighting of this aspect of the Society's work through the recent Annual Meeting Symposium is most appropriate at a time when the nation as a whole is becoming more "education-conscious."

R.E.H.

From the Four Corners . . .

Like most organizations that are visited by many distinguished guests throughout the year, ASTM Headquarters keeps a guest register in the first-floor lobby. We try to see that it is used faithfully, and we suspect that not many candidates get by without signing in.

Curiosity about the contents of the little book prompted us to look through it recently and compile a few statistics. We knew, of course, that people visit us from all over the world to exchange ideas with our Staff on standardization and materials research, but it is astonishing just how widespread this sort of thing is.

Since 1949, we have received visitors from 38 different nations—from Formosa to South Africa, from Pakistan to the Belgian Congo, from Indonesia to Nicaragua. We were somewhat surprised at first (although not so much so on second thought) to discover which nation had been the source of more visitors than any other: head and shoulders above all the rest was Japan. England was second, followed closely by France, Italy, and Germany. The only major land area not represented is Antarctica. Come to think of it, we don't have many members down there, either, that is permanently. Must be a correlation somewhere.

The telephone number at ASTM Headquarters has been changed. Our new number is LOcust 3-5315.

September 1—Last Day for Annual Meeting Papers Discussion

WRITTEN discussion of papers and reports presented at the Annual Meeting will be received by the Committee on Papers and Publications until September 1. In view of the fact that much of the discussion published in the *Proceedings* is submitted after the meeting by letter, it will be helpful if all who can will send in their discussion to Headquarters well in advance of this date so that additional time is available to review and refer the discussion to authors for closure.

MATERIAL QUESTIONS

NEARLY EVERY day the mail at ASTM Headquarters includes some questions about materials, specifications, test methods, or related problems. We feel that the answers, many of which are based on information given us by officers of committees in their capacity as committee officers, are of general interest. For the most part, inquiries we receive relate to the activities of the Society, either standards, research work, or publications. Often, an inquiry is such that the services of a consultant or independent testing or research laboratory is obviously required; in this event we do not hesitate to so recommend.

Cast Iron at Low Temperatures

We wonder if any ASTM committee has tentative specifications forthcoming covering ductile iron and gray iron castings at subzero temperatures. We are interested in what effects subzero temperatures have on the physical properties of castings. We have found various published articles concerning gray iron and ductile iron at low temperatures; however the tension tests were made at room temperature rather than at the subzero temperature.

● Committee A-3 on Cast Iron some time ago appointed Subcommittee 26 to consider specifications for cast iron for low-temperature applications. As yet the committee has been unsuccessful in preparing specifications or recommended practices. In reviewing data submitted to the subcommittee it was stated by committee members who produce castings for refrigeration equipment that a casting which performs satisfactorily at room temperature gave no difficulty at lower temperatures.

Data on cast iron at temperatures as low as −300 F may be found in "The Impact Properties of Flake Graphite Cast Irons," by G. N. J. Gilbert, *Journal of Research and Development*, The British Cast Iron Research Assn., pp. 298–317, Vol. 5, No. 6, June, 1954. Gilbert reports that the tensile strength of cast iron may increase slightly at low temperatures. Most of the emphasis by various investigators has been placed on impact properties because impact strength usually suffers more than any other single property in ferrous metals as they are cooled. In Gilbert's work it was found that the phosphorus content of the iron influenced the impact strength, but in most cases the impact strength at −150 F was roughly one half that at room temperature.

J. S. Vanick reported data on low-temperature impact strength of cast iron in *ASTM Special Technical Publication No. 158*, "Symposium on Effect of Metals with Particular Reference to Low Temperatures." His results also indicate that down to −300 F the impact strength of cast iron is roughly 50 per cent of that at room temperature.

Error in Part 9 of 1958 Book of ASTM Standards

An error appears in the Method of Test for Dilute Viscosity of Vinyl Chloride Polymers (D 1243–58 T) on page 531 of Part 9 and on the same page in the 1958 compilation, "ASTM Standards on Plastics." In the formula in Section 7, the number 2.303 should be deleted, so that the formula reads:

$$\eta_{inh} = \frac{\ln \eta_{rel}}{C}$$

Papers to Appear in Future Issues of the ASTM Bulletin

Low-Temperature Tensile Properties of Copper and Four Bronzes—R. M. McClintock, D. A. Van Gundy, and R. H. Kropschot, National Bureau of Standards.

Cyrogenic Engineering of Hydrogen Bubble Chambers—B. W. Birmingham, D. B. Chelton, and D. B. Mann, National Bureau of Standards, and H. P. Hernandez, Lawrence Radiation Laboratory.

An In-Place Strength Test for Low-Density Concrete—I. A. Benjamin and G. D. Ratliff, Granco Steel Products Co.

Continuous Powder Feed Explosivity Test Apparatus—W. D. Box, Union Carbide Nuclear Co.

Municipal Incinerator Refractories Practice—R. B. Engdahl and J. D. Sullivan, Battelle Memorial Institute.

The Effect of Brick Surface Texture Upon the Initial Rate of Absorption—P. T. Hodgins, National Research Council of Canada.

Measurement of the Crystallinity and Void Content of Articles Fabricated from "Teflon" TFE-Fluorocarbon Resins—N. G. McCrum, E. I. du Pont de Nemours & Co., Inc.

Comparative Study of Waterproofing Qualities of External Coatings Under Laboratory Conditions—I. I. Soroka, Israel Institute of Technology.

New Joint Sealer Testing Machine Developed—R. J. Schutz and Al Van Hauter, Sika Chemical Corp.

High-Stress, Low-Cycle Fatigue Properties of Notched Alloy Steel Specimens—S. Yukawa and J. G. McMullin, General Electric Co.

Schedule of ASTM Meetings

This gives the latest information available at ASTM Headquarters. Direct mail notices of all district and committee meetings customarily distributed by the officers of the respective groups should be the final source of information on dates and location of meetings. This schedule does not attempt to list all meetings of smaller sections and subgroups.

Date	Group	Place
Sept. 14	Committee D-22 on Atmospheric Sampling and Analysis	Philadelphia, Pa. (ASTM Headquarters)
Sept. 21–23	Committee D-9 on Electrical Insulating Materials	Cleveland, Ohio (Pick Carter Hotel)
Sept. 22–25	Committee D-20 on Plastics	Cleveland, Ohio (Pick Carter Hotel)
Sept. 22–24	Committee B-5 on Copper and Copper Alloys, Cast and Wrought	Washington, D. C. (Sheraton-Park Hotel)
Sept. 29–30	Committee C-22 on Porcelain Enamel	Columbus, Ohio (Battelle Memorial Inst.)
Oct. 7–8	Committee C-8 on Refractories	Bedford, Pa. (Bedford Springs Hotel)
Oct. 11–16	**Third Pacific Area National Meeting** Committees now scheduled to meet at West Coast meeting: B-2 Sub IX, C-1, C-7, C-9, C-13, C-19, D-2, D-9 Sub V, sections of D-14, D-18, D-20 Sub XVIII, E-2, E-9 Sub V, E-10.	**San Francisco, Calif. (Sheraton Palace Hotel)**
Oct. 13–16	Committee D-13 on Textile Materials	New York, N. Y. (Sheraton-McAlpin Hotel)
Oct. 15–16	Committee C-3 on Chemical-Resistant Mortars	Glens Falls, N. Y. (Queensbury Hotel)
Oct. 26–27	Committee B-1 on Wires for Electrical Conductors	Washington, D. C. (Sheraton-Park Hotel)

NEW ASTM PUBLICATIONS

ASTM Out-of-Print Books to Be Made Available

As a service to its members and to others seeking out-of-print ASTM publications, the Society has recently entered into a contract with University Microfilms, Inc., of Ann Arbor, Mich., to reproduce, by a combination of microfilm negative and Xerography, some of its publications no longer available. A new process permits the reproduction on a laid paper of one copy at a time of books within the size of 6 by 9 in. The approximate cost is $3^1/_2$ cents per page per copy including a paper binding, with a minimum charge of $2.50.

Presently the contract includes the following Special Technical Publications, for which there have been inquiries:

STP 12—Symposium on Effect of Temperature on the Property of Metals (1931)
STP 47—Impact Resistance and Tensile Properties of Metals at Atmospheric Temperatures (1941)
STP 63—Report on Behavior of Ferritic Steels at Low Temperatures (1945)
STP 32—Symposium on Corrosion Testing Procedures (1937)
STP 37—Compilation of Available High-Temperature Creep Characteristics of Metals and Alloys (1938)
STP 132—Symposium on Plastics Testing—Present and Future (1953)

As other ASTM publications go out of print, the contract will be extended.

Orders should be forwarded directly to **University Microfilms, Inc., 313 N. First St., Ann Arbor, Mich.**

Change in ASTM Year Book

Beginning in 1959, and in all odd-numbered years thereafter, lists of subcommittees and their officers will be published in the ASTM Year Book, but complete lists of subcommittee personnel will be omitted. In the even-numbered years, complete lists of subcommittee personnel will be published as before. This step is being taken in the interest of economy, in view of the increasing size and cost of the Year Book. Members who wish to have a list of subcommittee personnel should hold their 1958 Year Books until the 1960 Year Book is issued.

Despite this change, committee secretaries should note that lists of main and subcommittee personnel are needed at Headquarters before August 15 so that our records can be kept up-to-date.

Symposium on Bulk Quantity Measurement

The installation of automatic tank gages, temperature equipment, and positive-displacement meters is becoming widespread throughout the petroleum industry. In many cases, this equipment is being used for custody transfer, and this trend will certainly increase in the years ahead. While present ASTM standards include information on this equipment and its use as "information only," ASTM will eventually need to incorporate standard procedures, types of equipment, and standards for installation in the methods to cover automatic determinations. Since manual gaging is still the referee method and the method to which automatic equipment is compared, a discussion of the accuracy of hand gaging has been included in this symposium as well as a discussion of the other methods.

It is expected that this symposium will stimulate thought and discussion on the problems associated with standardizing procedures for the installation, operation, and maintenance of this equipment. Papers included are:

Introduction—P. L. DeVerter
How Accurate Is Hand Gaging?—C. L. Peterson and E. F. Wagner
Automatic Tank Gage Performance—H. E. Sims
Transfers Using Positive-Displacement Meters—Techniques and Procedures—M. A. Levy
Application, Installation, and Maintenance of Automatic Tank Gages—G. D. Robinson, Jr.
Suggested Standard Procedures for Use of Positive Displacement Meters in Custody Transfer Measurements—L. S. Wrightsman

STP 249, 56 pages, hard cover, price $2.25, to members $1.80.

Index to the Literature on Spectrochemical Analysis Part IV, 1951–1955

This is the fourth part of a series of bibliographical surveys of the literature on emission spectrochemical analysis. Previous parts covered the years 1920 through 1939 (1467 references), 1940 through 1945 (1044 references), and 1946 through 1950 (1264 references). This fourth part covers 1951 through 1955 and contains 1879 new references plus 12 for previous periods not previously listed.

The abstracts are largely quoted verbatim from *Chemical Abstracts*, but occasionally there are abridged or direct quotations from other publications. The source of the abstract is indicated following each reference. Efforts have been made to ensure completeness; however, reference to papers containing only a few qualitative results have generally been omitted. Bourdon F. Scribner and William F. Meggers of the National Bureau of Standards are the compilers for this book, which is sponsored by ASTM Committee E-2 on Emission Spectroscopy.

STP 41-D, 320 pages, hard cover, price $6.50, to members $5.20.

ASTM Issues New Section of X-ray Powder Data Cards

Section nine of the X-ray Powder Data Card File, covering approximately 600 inorganic and 400 organic materials, is now available in the Plain and Keysort card form. IBM forms will be available in mid-August. Prices will be as follows:

	Plain	Keysort	IBM
Part 1 (Inorganic)	$60	$95	$45 (two parts one unit)
Part 2 (Organic)	$70	$100	

A new Index book (Special Technical Publication 48-H) has also been issued, which is supplied without charge with each order of Plain or Keysort cards. Extra copies of this 700-page book can be obtained at $12 per copy. For shipments abroad all the above prices will be slightly higher. Educational institutions are eligible for a substantial discount from the above prices when the card file is used for classroom instruction.

X-ray powder diffraction analysis identifies a material by means of its atomic arrangement. It is therefore useful whenever it is necessary to identify the state of combination of the chemical elements or phases present, and can be applied to a mixture of several substances. It is used to a great extent for analysis of alloys, clays, corrosion products, industrial dusts, pharmaceuticals, minerals, refractories, and wear products. Instances of extreme usefulness in checking chemical processes have been reported. Compared with ordinary chemical analysis, the diffraction method requires only a small sample, is nondestructive, and is usually much faster.

This powder data file has been compiled by the Joint Committee on Chemical Analysis by Powder Diffraction Methods, sponsored by the American Crystallographic Assn., ASTM, the British Institute of Physics, and the National Assn. of Corrosion Engineers.

District Activities

NEW ENGLAND

Hot Gases, Cold Metal, Dry Humor

The Spring Meeting of the New England District, held jointly with the New Hampshire Section of the American Society of Civil Engineers, at Dartmouth College, featured five talks, including a technical discussion of the plasma flame and another on super-low temperatures. Dean William P. Kimball of Dartmouth's Thayer School of Engineering welcomed the 78 who attended.

Executive Secretary R. J. Painter, speaking on "ASTM in the Expanding Technology," told how ASTM is gearing itself to keep pace with the growing need for research and standards for materials. Mr. Painter observed that the two questions he hears most often are: (1) why does ASTM move so slowly, and (2) why does ASTM set up specifications in such a hurry.

In his talk, "ASTM—Democracy in Action," Vice-President A. Allan Bates compared ASTM to the earliest and most perfect democracy—Athens. In its standardization work, ASTM brings together in its technical committees people with conflicts of interest and provides them with a forum and a democratic system for reaching agreements in the best interests of all.

Dartmouth Professor James A. Browning spoke on "Plasma Flame—a New Heat Source." In addition to his work on the Dartmouth faculty, Professor Browning operates a commercial company producing plasma-flame equipment. The plasma flame is obtained by passing a gas, at high velocity, through an electric arc, where the gas is ionized and heated. Startling temperatures are attained—12,000 F is routine, 60,000 F is possible. A plasma-flame torch can cut steel four times as fast as an oxyacetylene flame. The torch will vaporize any known substance, hence can be used to spray-coat almost anything—for example, refractory materials.

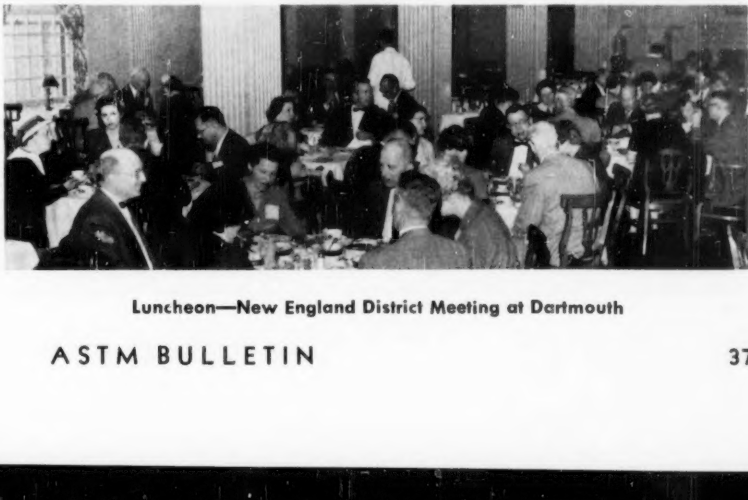
William Gifford, of Arthur D. Little, Inc., discussed "Engineering at Super-Low Temperatures." He defined this temperature region as being below about 85 Kelvin. Some materials exhibit strange behavior at these temperatures. While some metals become very brittle, others become more ductile. Ordinary steel becomes weaker, but stainless steel becomes very much stronger. Thermal conductivities of pure silver, copper, and gold increase by factors of 30 to 40.

Afternoon Speakers at New England Meeting

(From left) Browning, Gifford, Painter, Bates

Officers and Guests at New England Meeting

(From left) Emil A. Gramstorff, program chairman, dean, graduate division, College of Engineering, Northeastern University; S. Russell Stearns, chairman of local arrangements, assistant professor of civil engineering, Thayer School of Engineering, Dartmouth College; Ernest F. Walsh, district vice-chairman, assistant to superintendent of power plants, Narragansett Electric Co.; Francis J. Mardulier, New England District Council, manager, Cement Mill Products, Dewey & Almy Chemical Co.; William L. Glowacki, district secretary, assistant director of research, Eastern Gas and Fuel Associates; Walter J. Smith, New England District Council, chemical engineer, Arthur D. Little, Inc.; Randall H. Doughty, district chairman, research director, Fitchburg Paper Co.; Jerome B. Allyn, Dartmouth student, recipient of the Lester Memorial Award; William P. Kimball, dean, Thayer School of Engineering.



Luncheon—New England District Meeting at Dartmouth

ASCE New Hampshire Section Officers at Dartmouth Meeting

(From left) R. J. Prowse, vice-president; J. R. Kelsey, president; R. G. Kenevel, secretary.

Heat capacity decreases by a factor of 5000 to 6000—almost to the vanishing point.

"Vermont Humor" was the subject of the evening talk by Allen R. Foley, professor of history at Dartmouth. Professor Foley drew on a rich fund of anecdotes pointing up the foibles as well as the rock-ribbed integrity of the denizens of northern New England. The talk, delightfully embellished by professor Foley's own Yankee accent, was one of the most amusing ever delivered at an ASTM meeting.

Chairman of the Spring Meeting Committee was Dean Emil A. Gramstorff of Northeastern University. Former District Chairman S. Russell Stearns, professor of civil engineering at the Thayer School of Engineering, contributed a great deal to the success of the meeting.

WESTERN NEW YORK

New Fuel for Automobiles?

At a meeting May 8 at the Rochester Institute of Technology, David A. Hall, Eastman Kodak Co., was the featured speaker. His topic for the evening was "LPG a Fuel for Automobiles?" Following presentation of Student Membership Award certificates to students from eight Western New York colleges and universities, Mr. Hall described this application for liquid petroleum gas.

Actually, LPG has been used as a fuel for autos, buses, and trucks for many years. Among the arguments for its use, engineers have discovered, are low-cost engine maintenance; more complete combustion and, therefore, more power from the fuel; and better engine performance.

The increasing importance of this fuel has stimulated work by ASTM Committee D-2 on petroleum products. Both producers and consumers of the fuel are interested in establishing LPG standards. Tentative ASTM specifications have been published.

Some 60 people attended the meeting, and a stimulating question period followed the formal presentation. District Chairman, Charles Pope, of Eastman Kodak Co., presided.

Stopping Points on President Woods' Recent Western Trip

At left, enjoying a boat ride during the visit to Houston, are: Mrs. R. C. Anderson, wife of the new secretary of the Southwest District Council; Paul DeVerter, Humble Oil and Refining Co., past district chairman; H. H. Olson, chairman of the membership committee for the Southwest District, Sheffield Steel; and Frank Chairez, then district secretary, Eastern States Petroleum Co., now manager of Mexican Operations, National Aluminate Corp., Mexico City.

(Above) Members of the engineering faculty of Texas A & M College welcome ASTM to the campus at College Station. From left: Executive Secretary R. J. Painter; William E. Street, head, Engineering Drawing Dept.; Alfred E. Cronk, head, Aeronautical Engineering Dept.; Fred J. Benson, dean of engineering; Mrs. Benson; C. M. Simmang, head, Mechanical Engineering Dept.; Mrs. K. B. Woods; J. D. Lindsay, head, Chemical Engineering Dept.; Mrs. C. W. Crawford; C. W. Crawford, associate dean of engineering; J. G. McGuire, assistant to dean of engineering; Mrs. R. J. Painter; T. R. Holleman, head, Architecture Div.; S. A. Lynch, head, Geology and Geophysics Dept.; Glen D. Hallmark, head, Electrical Engineering Dept.; S. R. Wright, head, Civil Engineering Dept.; R. L. Whiting, head, Petroleum Engineering.

CENTRAL NEW YORK

Suitable Materials Needed

The newly organized Central New York District held its second meeting on Thursday, April 23, at Utica, New York. The meeting started with a guided tour through the plant of the Kelsey Hayes Co., Metals Division, and was followed by dinner and the meeting proper at Twin Ponds Golf and Country Club.

F. L. LaQue, vice-president and manager, Development and Research Division, The International Nickel Co., Inc., and ASTM vice-president, speaking on "ASTM—Now and Future," described very interestingly the self-analysis ASTM is now undergoing through the numerous subcommittees of its Long-Range Planning Committee.

The principal speaker, Dr. F. N. Darmara, president and general manager, Metals Division, Kelsey Hayes Co., spoke on "Vacuum Melting." Dr. Darmara, a pioneer in the field of vacuum metallurgy, referred to the many problems now facing engineers and metallurgists in developing metals suitable for use in the environments and under the stresses to which they are subjected. Vacuum melting offers opportunities to develop desirable properties which have not been previously available.

Among the specific metals problems to be designed for are aerodynamic heating; high strength-to-weight ratios, fatigue resistance, high-temperature bearings, and neutron absorption properties. According to Dr. Darmara, cleanliness, a characteristic of vacuum-melted metals, affects the resistance of many metals to fatigue and corrosion.

Up to ten years ago the Air Force found that most of its problems in developing instrumentation and mechanisms were in the engineering of them. Now, reports Dr. Darmara, suitable materials are the problem. Unless we have new materials or new techniques for developing and handling them, progress will stop.

Pointing to the development of new alloys and citing some specific examples, Dr. Darmara reported that in some instances, apparently with identical heats, physical properties varied widely even when analysis showed trace elements to be as little as 10 ppm. He conjectured that it may be that the amount of trace elements below 10 ppm could be the governing factor in the resulting properties, but that present analysis techniques do not permit the determination of impurities in these extremely low concentrations.

In new alloy development, Dr. Darmara stated, the speed of testing controls progress and not the engineer and

the metallurgist alone. For example, if a new alloy is developed and it is desired to reproduce it, tests made to control production must be suitable for analysis in a matter of hours and not in a matter of months or years.

The meeting was of absorbing interest throughout and concluded with discussion from the audience. The district is already planning its program for the next year or two.

CHICAGO

Two Hundred at Iowa State Hear President Woods

As part of a short trip through the Middle West, ASTM President K. G. Woods, head of the School of Civil Engineering at Purdue University, spent Tuesday, April 14, at Ames, Iowa, discussing engineering curricula with the faculty of Iowa State College. In the late afternoon, President Woods spoke on "Polar Construction" to a group of about 200. The talk dealt with the effects of frost action and permafrost on the design and construction of highways, airfields, railroads, and buildings in the Arctic and sub-Arctic.

All ASTM members in Iowa were invited to attend the meeting, sponsored by the Iowa State School of Engineering. Arrangements were handled by former Acting Dean M. S. Coover in collaboration with Engineering Dean George R. Town. Professor Woods was introduced by ASTM Honorary Member H. J. Gilkey, veteran member of the faculty at Iowa State and son-in-law of the late Arthur N. Talbot, past-president and honorary member of ASTM, who for many years was dean of engineering at the University of Illinois, where his memory is perpetuated by the Talbot Laboratory. The many active ASTM members at Iowa State include Glenn J. Murphy, chairman of the ASTM Administrative Committee on Education in Materials, who served on the joint ASEE-ASTM committee that arranged the Symposium on Education in Materials held at the Annual Meeting.

DETROIT

President's and Students' Night

A combination of President's Night and Students' Night is indeed a happy one—at least it proved to be so at the April 29 dinner meeting sponsored by the Detroit Council. The meeting was held at the Rackham Memorial Building, which of itself was conducive to a successful event in view of the excellent facilities provided.

Student Membership Awards were made to 19 members of the senior classes at four universities: University of Detroit, University of Michigan, Wayne University, and Michigan State University. These awards have been quite a feature with the Detroit Council over the years, and certificates are presented in the name of the Council as well as on behalf of the Society. The presentations were made by Associate Executive Secretary R. E. Hess, following a brief account of some of the Society's activities, with emphasis on the newer developments. The students were introduced by J. F. Leland, who has taken quite a keen interest in the Student Award program.

President Woods' talk on engineering in the arctic is of such broad interest that it has appeal for everyone, no matter what his particular technical field. The entire audience, students and members alike, were most attentive throughout the evening. There was quite a good attendance of some 150, including members and former members of the Board of Directors and Administrative Committees. The meeting was very ably handled by the chairman of the Council, Robert Sergeson.

At the Rocky Mountain District Meeting

Present at the highly successful meeting of our newest District last March were (left to right): District Vice-Chairman P. J. Elsey, assistant director, Engineering Experiment Station, University of Utah; District Chairman H. E. Montgomery, Sandia Corp.; ASTM President K. B. Woods; M. L. Merritt, Sandia Corp.; D. A. Sherar, Thiokol Chemical Corp.; J. W. Berg, Jr., Geophysics Dept., University of Utah; Rudolph Szilard, Colorado State University; J. F. Tracey, Radiation Laboratory, University of California; George Huber, Stanford Research Inst.; L. K. Irvine, acoustical engineer consultant.

PITTSBURGH

Pittsburgh Holds President's Night

ASTM President K. B. Woods was guest of honor of the Pittsburgh District at a meeting held April 30 in Pittsburgh. At the meeting, which was attended by one of the largest groups in the history of the Pittsburgh District's President's Night, Student Membership Awards were presented by President Woods to students from the University of Pittsburgh, Carnegie Institute of Technology, Pennsylvania State University, and West Virginia University. Following presentation of the awards, Professor Woods gave a short talk on his travels and work in the polar regions. The lecture was well illustrated with slides which he took in this area.

India Steels Herself

The National Metallurgical Laboratory, Jamshedpur, India, completed a triple play last February in the cause of steelmaking in India. First, NML sponsored a 4-day symposium on the "Iron and Steel Industry in India," which was attended by delegates from many parts of India, the Western European nations, Japan, Australia, and the United States. Second, NML published the first issue of its new quarterly *Technical Journal*, containing the following foreword by Jawaharlal Nehru:

> ". . . It is Science alone that could solve the problems of hunger and poverty, of insanitation and illiteracy, of superstition and deadening custom and tradition, of vast resources running to waste, of a rich country inhabited by a starving people . . . who indeed could afford to ignore Science today? At every turn we have to seek its aid . . . the future belongs to Science and to those who make friends with Science. . ."

The third event of the week was the inauguration of a low-shaft furnace pilot plant having a productive capacity of 15 tons of pig iron per day. Because of India's lack of coking coal, this pilot plant will be used to study the possibilities of making commercial grades of pig iron with raw materials like soft iron ores, iron ore fines, beneficiated magnetite iron ore, with various noncoking, high-ash coals or carbonized lignite, which are not suitable for use in conventional blast furnaces. By 1961, India plans to be producing ingot steel at the rate of 6 million tons per year.

Technical Committee Notes

Glass

Cooperation on Durability

Close cooperation between the U. S. Pharmacopoeial Convention and ASTM Committee C-14 on Glass is expected on questions of glass durability. This was reported at the May 20 meeting of the committee in Chicago. The Subcommittee on Chemical Properties plans to review existing ASTM test methods for possible revision to meet the requirements of the U.S.P. This will be coordinated with the Subcommittee on Glass Containers. Attention will be given to standard procedures for preparing water for testing, building and operating the water still and the autoclave, using sodium salt as an indicator, and making powder tests.

Existing chemical analysis methods are being revised; new colorimetric methods and procedures involving chelation are being developed.

The committee was told that the International Commission on Glass is considering as standard the ASTM annealing and strain point test methods for glass.

Ceramic Whitewares

Translucency Test Approved

Translucency has long been a feature of fine china demonstrated in every showroom. Committee C-21 on Ceramic Whitewares and Related Products, at its meeting in Chicago, Ill., on May 19, approved a standard method of measuring the translucency of fired whiteware products. In this method the whiteware is prepared in the form of a step wedge and the light transmission in foot-candles is measured.

Other methods in the final stages of completion are tests for Knoop hardness of ceramic tile glazed surfaces, alkali resistance of glazes, and solubility of lead glazes. Methods for complex dielectric constant, and ferrimagnetic resonance line width and gyromagnetic ratios of nonmetallic magnetic materials are also nearing completion.

New projects include development of standards for foamed ceramic materials, graphite for nuclear applications, and determination of organic constituents and soluble sulfates in clays.

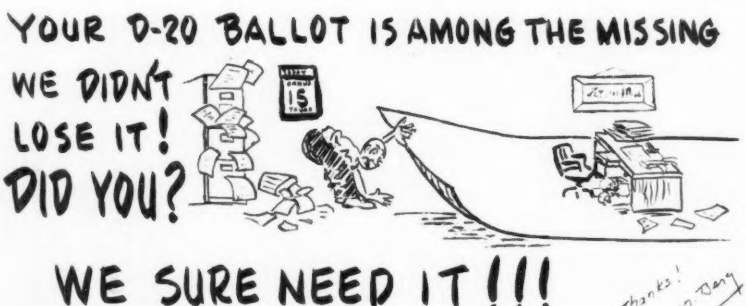
Electrical Insulation, Plastics

Rad Chosen Standard Radiation Dose Unit

The Joint Subcommittee on Radiation Effects of Committees D-9 on Electrical Insulation and D-20 on Plastics has recommended the use of the "rad" as a standard unit for reporting radiation dose. The rad, which represents 100 ergs of energy absorbed per gram of material, is independent of the kind of ionizing radiation (X-rays, gamma rays, beta rays, neutrons, etc.), as well as of the type of material being irradiated. In this respect the rad differs from most other units currently in use for measuring radiation intensity and radiation effects. For example, the well-known Roentgen unit applies only to X- and gamma rays absorbed by air. In order to use the Roentgen as a unit for measuring exposure to radiation of materials or tissues other than air it has been found expedient to use a modified unit such as the rep, which is Roentgen equivalent physical. The rep is defined as the dose of any nuclear or ionizing radiation that results in the absorption of 98 ergs per gram of tissue. The energy equivalent of the rep was formerly 93 ergs per gram but was changed because of more refined determination of *W*, the ion-pair yield for air, on which the Roentgen is based. The Roentgen is equivalent to 83.8 ergs per gram of air. Another unit, the rem (Roentgen equivalent man) is related to the rad in terms of another unit called the relative biological effectiveness, or RBE.

In recommending the use of the rad as the standard radiation dose unit, the committee is recognizing what was expected in 1953 by the International Commission on Radiographic Units when it adopted the rad as a new unit of absorbed radiation dose. It was expected then that the rad would eventually supersede the rep, which has been widely used in reporting radiation dosage. This action of the committee to recommend a standard unit, if widely followed, will improve communications among those individuals who are reporting the results of experiments on radiation effects. Data may be more easily compared and conclusions more readily drawn.

D. S. Ballantine of Brookhaven National Laboratory is chairman of the Joint Subcommittee on Radiation Effects; F. W. Reinhart, National Bureau of Standards, is chairman of the Plastics Committee, and H. K. Graves of the New York Naval Shipyard is chairman of the Electrical Insulation Committee.



D-20 Goes After Those Ballots

In a lively and imaginative effort to get out the vote, Committee D-20 on Plastics has been mailing eye-catching artwork like this to its members. Orchids to Committee Chairman Frank W. Reinhart and Secretary Robert M. Berg. The man behind the pen is Robert Eberbaugh, staff artist with the Industrial Relations Department of Union Carbide Chemicals Co.

Engine Antifreezes

New Test Programs

As part of a long-range program to improve the Method for Glassware Corrosion Test of Metals for Engine Antifreezes (D 1384), a third collaborative test program was initiated at the meeting of Committee D-15 on Engine Antifreezes held in Washington, D. C., April 14. The new program will compare new and old methods of coupling the metal coupons, and will also compare distilled water with synthetic tap water, using three typical antifreeze formulations.

Progress on the proposed test for determining the foaming characteristics of engine antifreezes has been difficult owing to the difficulty of obtaining a reproducible air diffuser source. A new interlaboratory study has been initiated to determine the efficacy of an alundum sphere as specified in Method D 892.

The apparatus for the mechanical bench equipment for simulated service testing of engine antifreezes was approved. This apparatus will use a commercially available water pump and radiator, coupled with a cast-iron reservoir to hold the metal corrosion coupons. The system is designed to contain the same volume of coolant as a typical automobile system. Thirteen laboratories are purchasing reservoirs for use in a collaborative program to evaluate this equipment.

Joint Committee on Effect of Temperature Seeks Research Funds

A CAMPAIGN to raise $150,000 to finance several current and projected research projects in the field of high and low-temperature metallurgy was inaugurated recently by the Joint Committee on Effect of Temperature on the Properties of Metals, which is sponsored by the ASME and ASTM.

An illustrated brochure along with a letter soliciting funds has been sent to leading organizations concerned with the problems under study by the Joint Committee. This brochure describes the research projects now in progress and those scheduled for the future. The committee states that these two phases together with other anticipated needs for the next several years indicate a sum of about $150,000 will be required.

The current research activities covered by formal agreements include work on:

1. High-temperature data on aluminum and magnesium alloys,
2. Austenitic steels for steam line service,
3. Calibration specimens for creep testing,
4. Elevated temperature properties of cast iron (recently completed),
5. Fatigue,
6. Thermal shock,
7. A punched card system for recording data on properties of metals.

New Research

Several projects planned for the immediate future are of urgent significance to industry; these projects, as described in the brochure, include:

1. Investigation of failures in superheater tubes,
2. Material evaluation,
3. Notch behavior, creep damage, and cyclic loading,
4. Elevated temperature test methods under rapid heating and rapid loading conditions,
5. Survey on mechanical properties of metals at low temperatures,
6. Effect of long time service on elevated temperature properties of tubes in power plant service.

In addition to this type of work the committee has over the years undertaken projects which do not require allocation of specific funds, the work being contributed by committee members and their companies and handled in other ways. From these cooperative activities come many benefits, including important data on problems in the field.

Since its inception in 1925, the Joint Committee has undertaken only five fund raising campaigns (1927, 1930, 1936, 1939, and 1951) to which industry has subscribed a total of about $150,000. With this modest sum the committee has sponsored a large volume of research since 1927. At the same time it has focused metallurgical attention on areas needing research, and catalyzed contributions (services, materials, and equipment) which are many times the actual cash funds contributed. At the present time, no unobligated balance remains from its funds raised several years ago—about $85,000.

Contributions for Joint Committee projects are deposited in a special custodian account administered by the ASME and are expended only on authority of the Joint Committee.

Know Your Committee Officers

To better acquaint Bulletin readers with the men who direct the indispensable work of the ASTM technical committees.

Committee E-15 on Analysis and Testing of Industrial Chemicals

W. A. Kirklin
Chairman
Hercules Powder Co.

E. G. Wiest
Vice-Chairman
E. I. du Pont de Nemours & Co., Inc.

J. T. Woods
Vice-Chairman
American Cyanamid Co.

R. C. Johnson
Secretary
Manufacturing Chemists Assn.

Eminent Men of Science and Engineering

... A New Feature Beginning in This Issue

About two years ago, then ASTM President R. A. Schatzel and Executive Secretary R. J. Painter, during a visit to the University of Illinois, were attracted to an extensive series of photographs on the walls in the corridors of Talbot Laboratory (named for Dr. Arthur N. Talbot, one-time ASTM President and a pioneer educator in the field of materials). These photographs were of scientists, engineers, and mathematicians who had made outstanding contributions to our knowledge of engineering materials and theoretical and applied mechanics.

Together with brief biographical sketches, these photographs had been assembled over many years by Prof. Jasper O. Draffin, of the Department of Theoretical and Applied Mechanics, whose diligence has produced a unique and most interesting collection.

Feeling that the historical value of this collection would have a widespread appeal among Bulletin readers, the Society officers arranged to have copies of the photographs made available for publication. The photograph below is the first of the series.

The Society is indebted to the University, and particularly to Prof. Thomas J. Dolan, head of the Department of Theoretical and Applied Mechanics, who was instrumental in making the material available to us.

Sir Isaac Newton (1642–1727). First stated the binomial theorem and the elements of the calculus. His greatest work, embodied in the *Philosophiae Naturalis Principia Mathematica*, formulated the laws of motion of heavenly bodies, which reigned supreme in the science of celestial mechanics for 200 years.

"For the best and safest method of philosophizing seems to be, first diligently to investigate the properties of things and establish them by experiment, and then to seek hypotheses to explain them. For hypotheses ought to be fitted merely to explain the properties of things and not attempt to predetermine them except in so far as they can be an aid to experiments."

...Isaaci Newtoni Opera

This is one of a series of photographs from a collection compiled by Prof. Jasper O. Draffin and displayed in the Arthur N. Talbot Laboratory, University of Illinois.

Soviet Russia Poses a New Industrial Threat

By RAYMOND EWELL

In 1957, Dr. Ewell spent 23 days and traveled 5000 miles in Soviet Russia, visiting universities, research institutes, and industrial plants. This address, which was presented at a New York District meeting on April 23, grew out of that experience.

DR. EWELL, a native of Massachusetts, with a Ph.D. in chemistry (Princeton, 1937) is an authority in the field of chemical economics. He has been a chemical economist for the Shell Chemical Corp., manager of the Chemical Economics Service at Stanford Research Inst.; founder and first editor of the Chemical Economics Handbook; adviser on industrial research to the government of the Philippines for the National Science Foundation, of which he was assistant director; industrial development adviser to the government of India for the Ford Foundation; and is now vice-chancellor for research at the University of Buffalo. He is the author of more than 60 articles and book chapters in the fields of chemistry and economics.

MOST Americans now realize that we are engaged in a great struggle with the Soviet Union, that the Soviet Union is growing in industrial and military power, and that our position *vis-à-vis* the Soviet Union is steadily declining.

However, the vast majority of Americans, at least 99.9 per cent, still do not fully realize that—

1. The United States is in by far the greatest peril of its history,
2. The Communist leaders of Russia really are planning to dominate the whole world, including the United States,
3. The struggle in which we are now engaged is the climactic struggle of history, which will decide the history of the world for the next few hundred years,
4. We are up against a completely new social and political force which did not exist 42 years ago,
5. The Communist threat will probably be the dominant factor in shaping all our lives during the next decade,
6. This struggle will come to a climax probably in 10 to 15 years,
7. We are in real danger of losing this struggle, and
8. We have only a few more years of grace before we must gird our loins and begin to fight in earnest.

These are strong statements. But the fact is it is impossible to realize these things unless one has actually been to Russia within the past few years. No matter how well-informed a person may be, how many lectures he hears, how many books he reads, the only way for him to truly grasp the Russian situation is to go to Russia and feel the throbbing power of that country, see their schools and factories, and above all observe the dynamic character of the Russian people.

The industrial growth of the Soviet Union during the 30 years since they started their first Five-Year Plan in 1928 has been the greatest industrial development of any country in history in a like period of time. They have advanced from sixth place in industrial output among the countries of the world in 1928 to third place in 1937 and to second place in 1945. From 1928 to 1958, their over-all industrial output increased by 28 times. For example, steel production increased from 4.7 million tons in 1928 to 60 million tons in 1958, electric power from 5 to 233 billion kilowatt-hours, coal from 39 to 546 million tons, cement from 11 to 195 million barrels, petroleum from 86 to 836 million barrels, tractors from 1300 to 220,000.

A Street in Moscow

"...the only way...to truly grasp the Russian situation is to go to Russia and feel the throbbing power of that country, see their schools and factories, and above all observe the dynamic character of the Russian people."

Today, the largest steel mills and the largest electric power plants in the world are in the Soviet Union. The Soviet Union is now outproducing the United States in coal, machine tools, railway equipment, timber, iron ore, aluminum ore, nickel, tin, manganese, wool, milk, butter, and sugar. In 3 or 4 years they will be outproducing us in meat, cement, fertilizers, and some other products. Their new Seven-Year Plan, which started in January, 1959, and runs through 1965, calls for an 80 per cent increase in over-all industrial production—for example, increasing steel production to 95 million tons, electric power to 500 billion kilowatt-hours, cement to 440 million barrels, and petroleum to 1.7 billion barrels.

These are tremendous accomplishments. However, this development would pose no particular threat to the United States if it were not for the fact that this enormous power is in the control of a highly organized ruling class,

the Communist Party, which is dedicated to the idea of world domination. This is a religious motivation and to be realistic we must look upon Communism as a militant religion with all the powerful driving forces which historically have always been associated with militant religions. If it were Switzerland or India or Brazil that was developing this great industrial potential, we would have little cause to be concerned—in fact, we would applaud it as a useful contribution to the world's productive capacity. But when this great power is in the hands of a militant clique bent on unlimited expansion and world domination, every free nation in the world, including the United States, is in peril. As long as the religious fervor of the Communist leaders continues, we will be in great danger, probably increasing from year to year. We cannot count on this religious fervor subsiding for at least a generation, and the climax of this struggle seems likely to come before then—probably within 10 to 15 years.

Despite the great industrial development in the Soviet Union, their industrial capacity today is still only about half that of the United States. However, their industry has been growing at the rate of 10 to 15 per cent per year since 1945 and appears likely to grow at the rate of 7 to 9 per cent per year during the next seven years. By comparison, our industrial capacity has been growing at only about 3 per cent per year and appears likely to continue at about this same rate. In 1950 the total industrial capacity of the Soviet Union was 25 to 30 per cent of the United States', in 1958 it had increased to about 50 per cent, in 1965 it seems likely to be approaching 75 per cent. In my opinion this will be a critical point. The Soviets will probably be on a par with the United States in the capacity to carry on a struggle—either military or economic—when they have reached about 75 per cent of our industrial capacity. The basic reason for this is that Russia is a nonluxury civilization. The 20 to 25 per cent of our industrial output that we now put into luxuries is one of our weaknesses in this struggle. The Russians have few luxuries and aren't likely to have many more even by 1965. Therefore, they are able to carry on a struggle with less total industrial capacity than we are.

The industrial development of the Soviet Union represents a danger to the United States for three principal reasons:

1. The Soviet Union's industrial development is the basis of their military power.
2. The Soviet Union appears certain to enter the field of international trade as a strong competitor.

Palace of Science at the University of Moscow, Completed in 1953 at a Cost of $300,000,000, Contains 2200 Scientific Laboratories.

"The United States is in by far the greatest peril of its history."

3. Greater international trade by the Soviets will inevitably lead to increasing political and cultural ties with many countries, which in turn may lead to political control.

We can expect the Soviets to challenge us with increasing frequency and severity as their industrial power increases. They know that their industrial power at present is not enough to challenge the United States in earnest. They are now playing a cat-and-mouse game in such areas as the Middle East, Formosa, and Berlin. These are purely probing operations to see how far we will go. But during the next decade, as their industrial power with respect to the United States steadily increases, their challenges will become more and more severe, more and more in earnest. We will need the very highest quality of leadership to deal with these challenges which seem sure to come. The way things appear to be developing now, I would expect the real danger point to come in the period from 1965 to 1970, for that appears to be the time when their industrial capacity will approach 75 per cent of ours. Despite all the talk about missiles, atomic bombs, and nuclear submarines, the real danger lies in the growth of their industrial power.

We have only a few more years of grace, only a few more years of taking life easy, only a few more years of business as usual. Then we will have to gird our loins, jettison many of our luxuries, and get ready to combat the Russian menace in earnest. Our opponent has been on a war basis for 30 years and we will have to get on a war basis, too, if we want to survive.

The Soviet potential in the field of international trade intensifies this picture. The Soviets have become active in international trade only during the past year or two, except within the Communist group of countries. Heretofore they have not had any surplus of goods they were willing to divert to international trade. Now they have some, and they will have more during the next years. This may develop very rapidly. For example, in 1958 the Soviet Union exported cars and trucks to 38 different countries. They told me in Russia that they expect to export large quantities of all types of manufactured goods during the next 5 to 10 years—automobiles, trucks, railway equipment, machine tools, electrical, radio and television equipment, typewriters, watches, cameras, chemicals, textiles. The Soviets are in a good position to do this, for they can produce goods more cheaply than we can and they are perfectly capable of meeting any quality standards that may be needed. They have a large, intelligent labor force, the best natural resources in the world, modern industrial plants and technology, plenty of well-trained engineers, and most important of all, a low wage scale. They can probably produce nearly any product at a much lower cost than the United States or any country of Western Europe. At the very least this development could seriously cut into our present international trade. And we must realize that the Soviet Union is likely to be by far the toughest competitor we have ever come up against in international trade.

In addition to their strong position costwise, the Soviets will have the advantage of a political motivation in their international trade program. They can be expected to enter into international trade with the intention of making a profit whenever possible. This should be quite possible with their lower costs. And they can be expected to do this vigorously and aggressively. However, if they can't make a profit, they will enter into international trade anyway for political reasons. In other words, international trade is an

(Continued on page 47)

Expanding Horizons in Analytical Chemistry

By C. M. GAMBRILL

The place of the analytical chemist in modern industry has grown rapidly in importance. He is being asked to tackle ever more complex problems, but newer tools and techniques have multiplied his abilities. The technology is moving ahead at a rapid pace. "The research of today will . . . become the routine of tomorrow."

This is an abridgment of the Anachem Award Address presented by Mr. Gambrill at the Sixth Annual Conference of the Association of Analytical Chemists last fall. Mr. Gambrill, analytical coordinator for the Research Laboratories, Ethyl Corp., is chairman of the Research Division on Elemental Analysis of ASTM Committee D-2 on Petroleum Products and Lubricants.

Not too long ago the analytical chemist was somewhat the problem child of the laboratory. He was treated with something like enforced tolerance, and any discussions of research programs or plans regarding analytical work were seldom a part of his activity.

Sampling, and the use of the right analytical method were subjects of little concern until an error occurred or something else went wrong. The analyst frequently was confronted with unusual requests or with large sample loads but was given little or no background information as to what was actually needed. He was expected to analyze anything by the chosen method and to do it in the twitch of an eyelid, regardless of time, effort, and possible research that might be required. Too often, the chemist who wanted an analysis had more than one choice of laboratory to which he could submit his sample. There was the routine inspection laboratory, the chemical analysis section, and the instrumental or physics section. These were the three main divisions; if X-ray was available, this was another group which possibly could handle certain needs.

The picture is quite changed today, at least in the larger laboratories. It is now generally recognized that analytical services should be integrated to obviate the practice of chemists or engineers shopping around to get their problems solved.

J. K. Roberts, director of the Standard Oil Co. (Ind.), has defined an analytical chemist as one who has "the ability to carry out analyses and be technically expert in so doing. Although he may not carry out all of the manipulation, he should be thoroughly acquainted with all phases of the work, recognize or evaluate unusual phenomena observed during the course of an analysis, and continually be aware of features of individual analytical methods which will limit or favor their use in particular cases. A broad knowledge of the many analytical methods and techniques must be at his finger tips.... Where no suitable method is at hand, he should be capable of developing one....A complementary requirement, often woefully lacking in the undergraduate applicant today, is the ability to report the results of his own work in concise and readable form. An additional asset is the ability to train and supervise nontechnical people. The opportunities for the chemist with such talents are not often recognized outside the industrial laboratory."

Analysis today is a more complex business than ever before. Not only does a host of new materials or combinations of materials come out of the many research programs, but also more and more attention is being paid to the less common elements. To complicate matters further, more information is being requested by research people on smaller and smaller samples and lower and lower concentrations of components.

In Walter Murphy's editorial in the October, 1955 issue of *Analytical Chemistry*, he said, "To select the best and most economical analytical method requires an analytical department equipped and staffed with qualified personnel in all phases of analyses. When this is done, only an outline of the information required is necessary and the analytical group decides what is best to obtain the required information." It is this type of operation that builds the enthusiasm, initiative, and loyalty that makes for smoothly operating analytical units.

Now let's consider organization. Not very many years ago, analytical laboratories were nonintegrated units established to handle certain types of analysis. These groups often competed with each other on service problems and sometimes produced more harmful than beneficial data. This resulted either from lack of interest in the problem or from inadequacy of experience, background information, or development of methods. As the various types of instruments were improved and could be adapted to analytical service problems, the chemists took them over, and a gradual build-up of instrumentation within the chemical analysis group became evident. Instruments provided more rapid determinations, and more often than not gave more information than could be obtained by available chemical methods.

This shift in effort brought about a much needed fundamental change. The several analytical units were organized into one group to better coordinate the work. This placed the analytical group at a higher level in the organization and gave it greater status in the over-all operations of the laboratory. Consolidating the effort in this fashion improved the service to a great extent and, at the same time, brought the analyst into more prominence as an integral part of the research organization.

Coordination of operations is now an essential factor in the success of the analytical group. Good analytical work cannot be accomplished from an ivory tower. Given creative cooperation by the research workers, analysis can become the spark plug of progress rather than the well-known bottleneck.

Outside interests, technical society

activities, and cooperative studies with other laboratories are other assets which need to be developed to round out the analytical operations.

The rise in importance of the analytical groups in technical societies undoubtedly is related to the cooperative trend in research. Two groups in which I have been active are ASTM, particularly in Committee D-2 on Petroleum Products and Lubricants, and the American Petroleum Institute's Committee on Analytical Research.

In Committee D-2 the work relating to the development of methods of test may originate in either a research division or a technical committee. When the need develops for a new method of test for some specific property of a petroleum product, a certain amount of exploratory work is done in the individual laboratories of the members. After selection of the most promising method, cooperative work is conducted to determine its precision and accuracy. If these tests provide adequate, letter ballots on the test are conducted to obtain a fair appraisal of the method before it is approved as a standard.

Considerable analytical effort and cooperation is required, and it is through this cooperative effort that progress is made. Consultations on techniques, manipulations, and other facets of a method all together assist in establishing methods which are best for all uses and help to promote improved techniques as standards.

The objectives of the Committee on Analytical Research of the American Petroleum Institute's Division of Refining are to promote the interests of the petroleum industry through study of chemical and physical analyses. This committee does not concern itself with standards on petroleum or its products, which is the difference between the ASTM and API activities.

Work in the Committee on Analytical Research may be similar to a large extent to that of ASTM—for example, the development of improved techniques for determining sulfur in fuels and trace metals in petroleum, spectrographic analyses of lubricants, and others. However, the work is transferred to ASTM as soon as buyer-seller relationships develop and the development of standards proceeds.

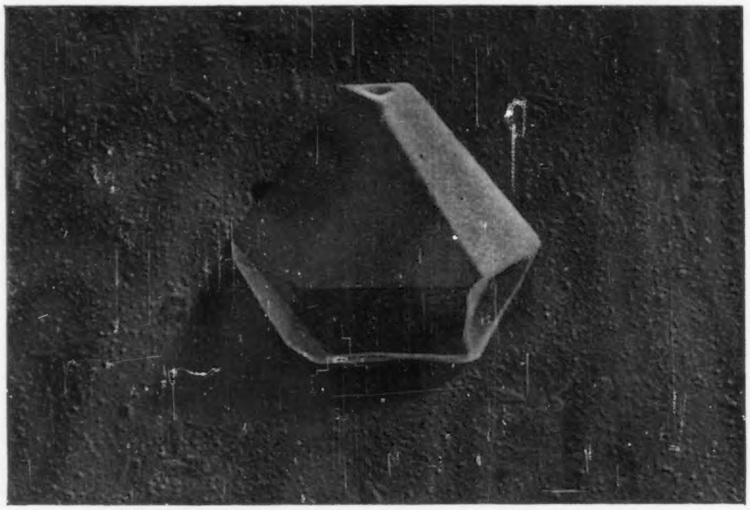
Independent research on new analytical techniques or development of improved methods on petroleum or its products is supported by the API. Two such programs under the sponsorship of the Committee on Analytical Research should be mentioned because of developments to come: One, the determination of trace metals in petroleum materials is being conducted by Dr. Bert Vallee at the Harvard Medical School. A cyanogen-oxygen flame spectrometer has been developed which permits determination of elements by flame spectrometry wherein interference occurs with the hydrogen-oxygen flame. Lower concentrations can be detected, and for quantitative work a recording spectrometer is being developed for channels for iron, nickel, chromium, vanadium, calcium, magnesium, cobalt, manganese, copper, and sodium. It is hoped that this technique, which should be available commercially before long, will be of significant value for obtaining information on trace or microgram quantities of metals in petroleum products.

The other program developed from some service work and standardizations in ASTM Committee D-2. Several years ago the railroads had a problem in the analysis for wear metals in the lubricating oils of diesel engines. A number of emission spectrographic methods for this analysis were cooperatively tested, evaluated, and later published in the ASTM Special Technical Publication No. 214 (1957). One of the shortcomings of these methods was the lack of organometallic compounds of sufficient purity for method standardization. This need was recognized and a project, sponsored by the API, is now in progress at the National Bureau of Standards. New compounds have been prepared and it is hoped that pure, stable, and compatible organometallic analytical standards will be commercially available by late 1959 or early 1960 for standardizing chemical and instrumental methods for the determination of metals in organic materials.

Now, let us consider how modern instrumentation has multiplied the analyst's abilities. Analytical chemistry not many years ago involved primarily elemental analysis, with some work done on functional analyses in both inorganic and organic chemistry. The science of analytical chemistry was primarily the science of measurement applied to the relatively few chemical reactions that could be made to follow a stoichiometric equation. The ultimate in analysis was to take a sample and so analyze it that a total of 100 ± 0.2 per cent could be accounted for. The badge of success was the number of determinations that could be made on one sample by one chemist.

Today, analytical chemistry involves all of the science of measurement. It involves the application of complicated instruments to complex systems without prior separation. Each quantity to be determined is measured on a separate sample without destroying the sample. Among the complex and automatic analysis tools is a mass spectrometer with a Sadic that types out the answer. Steel mills use quantometer spectrographs to record the impurity metals in a sample in the laboratory and transmit the answer to the furnace rooms at the same time. Direct-reading and controlling devices are the rule rather than the exception.

More recently, even more complicated solutions to difficult problems have been



Preshadowed Carbon Replica of du Pont Crystal Violet Dye

Crystal was shadowed with Pt-Pd (3:1) then coated at normal incidence with carbon. Crystal was then dissolved in water and the replica photographed. The original crystals are too opaque to permit adequate study of their surface structure. With the carbon replica technique, front, side, and top views are reproduced. Original magnification 9000 ×, final magnification 75,000 ×. Honorable Mention, Electron Micrographs, Non-Metals; Eleventh ASTM Photographic Exhibit. Walter S. Kay, E. I. du Pont de Nemours & Co., Wilmington, Del.

devised. One laboratory has worked out a computer program along with an infrared spectrophotometer so that the analysis is typed out when a card containing the spectrum is fed into the computer. The spectrum of the sample corresponds to the composite spectrum represented by analysis at 340 calibration points. With little more effort, 1000 points can be used. Furthermore, this application makes it no longer necessary to know the identity of every component in the mixture. If an extraneous impurity is present, the computer will type out the analysis and record a residual spectrum of the impurity to permit its identification.

Gas chromatography techniques—a laboratory curiosity five years ago—are today a major tool of the laboratory. Every day one hears of another advance in this rapidly growing technology, not only for analysis, but also for application to process controls.

Automatic X-ray fluorescence instruments are being developed for the analysis of steel and alloys of high atomic number elements. This technique, which permits analysis without sample destruction, may prove more accurate and more rapid than the presently available procedures. The method may have further application and advantages in the analysis of the new alloys being developed for high-temperature operations in this jet age.

What are some of the problems to be resolved and what are some trends? The development of rapid and inexpensive tests to accurately predict fuel performance is urgently needed. Until recently, it was no problem to supply motor fuels that satisfactorily met the requirements of automotive engines, and ratings at ± 0.5 octane number were adequate. The trend today to engines of higher compression ratio and the resulting need for fuels of 100-plus octane number make this task of fuel rating more difficult. The significance of improved engine ratings is quite evident when it is realized that existing tests are not adequate to predict ratings closer than ± 0.2 to 0.3 octane number; this degree of uncertainty costs the petroleum industry millions of dollars a year.

Of even greater importance is the need for a new test engine that will relate the octane number of a fuel to its performance in typical cars on the road. Stated in another manner, road ratings and laboratory ratings of fuels must be brought into closer agreement. For this purpose, improved instrumentation and more rapid rating methods are receiving considerable attention today. When it is realized that 75,000 ratings requiring approximately 30 to 60 min each are made each year, the savings in man-hours resulting from any improvement becomes significant.

Analysis for concentrations of contaminants at levels of parts per billion are now commonplace, and the extension of analytical techniques to lower and lower limits is the constant goal of the petroleum analysts. For example, feed streams to platformers now have to be carefully checked for contaminants at levels of 50 ppb for lead, 10 ppb for arsenic, and similar low levels for nitrogen and chlorine. Altogether, the problems are most challenging.

In an editorial entitled "New Analytical Methods Challenge Old Ones" in the February, 1958, issue of *Analytical Chemistry*, L. T. Hallet stated:

> Classical methods of determining elements or groups are based upon chemical reactions or decomposition under specified conditions. These methods, the results of years of research and testing by analytical chemists, are considered the standards by which all other methods are judged.
>
> Newer methods, based particularly on nondestructive physical approaches, are beginning to cast some doubt on the accuracy of some time-honored procedures. . . . More recent is the utilization of nuclear magnetic resonance as a nondestructive method for determining adsorbed water and water in the molecules. Infrared studies of functional groups are proving more accurate than some of the more conventional chemical methods. Viscosity measurements which differ depending on the method used have long been a controversial subject. Ultrasonic methods do not disrupt the system under study and so probably give a more accurate indication of true viscosity. When the validity of results obtained using the newer physical methods is proved, the physical methods will probably become the standards by which chemical methods are judged.

During the next few years we can expect an increasing flow of new materials, new metallic alloys, and new machinery—developments coming out of long-established research programs of industry. Along with these developments, the analytical chemist will play his part in the development of new analytical techniques, new instrumentation, and new concepts to make these new products a reality. It is no wonder that the neophyte chemist has a rude awakening on graduating from qualitative and quantitative studies to the vast array of techniques and methods in this expanding field of analytical chemistry.

How long to push-button analysis and a specific reagent for each element is strictly a guess. Although many of the procedures referred to are still in the research and development stages, the research of today will in many cases become the routine of tomorrow.

Russia

(*Continued from page 44*)

instrument of national policy with the Soviets, whereas American industry is just not geared to doing business on a non-profit basis for political reasons.

It would be my guess that the long-range strategy of the Soviets is to expand their international trade steadily with one country after another, offering as good terms as they have to to get the business. Then will come Soviet businessmen, advisers, and technicians by the thousands, as I observed them in India. Closer economic ties lead to closer cultural and political ties. Through this process Russia hopes to wean one country after another to their side, or at least convince them they should be neutral. By this process they might in 10 to 15 years get most of Asia and Africa on their side. In South America, too, the Russians are actively doing business and the neutralization of South America is not beyond the realm of possibility. If these developments were to materialize, Europe would be effectively neutralized, leaving the United States and Canada back-to-back as the last strongholds of freedom.

The Russian Jet Transport, TU-104, Has Been Flying on a Commercial Basis Since March, 1956

". . . the Soviet Union is likely to be by far the toughest competitor we have ever come up against in international trade."

What can be done to counteract this grim picture? First and foremost we need to develop a national purpose, to decide what we stand for in the world and get out and sell this aggressively to the rest of the world. Second, we need to develop a positive, dynamic long-range foreign policy to replace the passive, defensive day-to-day foreign policy we have had since 1945. This will probably mean a greatly expanded foreign aid program, even if it hurts U.S. taxpayers. Third, we should accelerate our military preparedness, even if it hurts. Fourth, for the longer pull we need to invest more money in education and scientific research.

This is the most desperate situation that this country has ever faced, but with realistic thinking, hard work, pulling in the belt, and a resurgence of the pioneer spirit that built this nation, we can survive with freedom and honor.

Proposed Tentative Method of Test for

Cement Content of Freshly Mixed Concrete

(Published as information only)

This method of test is published as information at the request of Subcommittee III-c on Methods of Testing Fresh Concrete of ASTM Committee C-9 on Concrete and Concrete Aggregates. It utilizes the principle of heavy liquid separation of cement from aggregate which was first proposed by W. G. Hime and R. A. Willis[1] and is a refinement of the original procedure proposed by them. It is published with the request that any data derived from its use be forwarded to Subcommittee III-c to aid in evaluating its usefulness. The text that follows is the latest revision dated March 11, 1959, considered by Subcommittee III-c with editorial revisions approved on April 17, 1959.

Scope

1. This method describes a procedure for determining the cement content of a sample of freshly mixed concrete using a heavy liquid and a centrifuge process for separating cement from the other ingredients of concrete. It is primarily applicable to concrete mixtures made with portland cement as the only cementitious material. The test is intended for research and experimental purposes.

Apparatus

2. The apparatus shall consist of the following:

(*a*) *Metal Stirrer*—A metal stirrer approximately 2 ft long with a spatula-like end approximately 1 by 3 by $\frac{1}{8}$ in., and bent to an angle of approximately 30 deg to the shaft.

(*b*) *Wire Cloth Basket*—A wire cloth basket $4\frac{1}{2}$ in. in diameter and 6 in. high with bail. The basket shall be made using 560-μ (No. 30) woven wire cloth meeting the requirements of Standard Specifications for Sieves for Testing Purposes (ASTM Designation: E 11).[2]

(*c*) *Centrifuge*—A motor-driven centrifuge capable of exerting a range of relative centrifugal forces in a stepwise or continuous range from about 150 to about 550 at the closed end of the centrifuge tube (Note 1). The centrifuge cups shall be of the proper size for holding the centrifuge tubes listed below.

NOTE 1.—Relative centrifugal force (RCF) is defined by the equation RCF = $0.00001118\ n^2r$, where n is the speed of rotation in revolutions per minute, and r is the radial distance of the closed end of the tube from the center of rotation, in centimeters.

(*d*) *Centrifuge Tubes*—Short, tapered centrifuge tubes of heavy-duty pyrex glass, having a capacity of 40 ml.

(*e*) *Hot Plate*—A hot plate with a capacity of about 30,000 Btu per hr and having a burner about 5 in. in diameter with a controllable flame.

(*f*) *Balance*—A balance, capacity 2500 g and sensitive to 0.1 g.

(*g*) *Hydrometer*—An hydrometer with a density range of 2.00 to 3.00 g per ml, and graduated in increments of 0.01 g per ml.

(*h*) *Scoops*—One metal scoop, size 0 (scoop part $2\frac{1}{2}$ in. wide and 4 in. long) and one size 1 (scoop part 4 in. wide and 6 in. long).

(*i*) *Weighing Pans*—Two aluminum weighing pans about 5 by 9 in. by $2\frac{1}{2}$ in. deep.

(*j*) *Skillet*—Cast iron skillet approximately 10 in. in diameter by 2 in. deep.

(*k*) *Metal Container*—A metal container suitable for holding a 2-kg specimen of concrete for weighing, having a shape such as to facilitate complete removal of specimen.

(*l*) *Miscellaneous Items*—(1) beaker, 3000-ml, pyrex glass; (2) asbestos gloves; (3) two 2-in. paint brushes; (4) glazed paper, black; (5) flask, flat-bottom, vial neck, 1000-ml capacity; (6) cylinder, glass, graduated, 250-ml capacity; (7) cylinder, glass, graduated, 10-ml capacity; (8) spatula, blade and spoon, porcelain, about 125 mm long; (9) rod, stainless steel, $\frac{1}{8}$ in. in diameter and 10 in. long.

Liquids and Chemicals

(*a*) *Heavy Liquid*—Acetylene tetrabromide, specific gravity 2.96 ± 0.02, shall be used as the heavy liquid when determining the portland cement content of concrete. If natural or other cements are to be determined, the acetylene tetrabromide shall be mixed with carbon tetrachloride (**Caution,** Note 2) or fuel oil in such ratios as to cause the cement to sink and the fine aggregate under test to float.

NOTE 2: **Caution.**—Carbon tetrachloride is toxic, both by absorption through the skin and by inhalation. Acetylene tetrabromide should also be used with care. Follow the directions on the supply bottles. Provide adequate ventilation.

(*b*) *Wash Liquid*—Acetone, technical grade or better, shall be used. This chemical is toxic and must be used with adequate care and ventilation. It is also flammable, and beakers containing appreciable quantities of it should not be heated over an open flame.

(*c*) *Chemicals*

(1) Santomerse S (Monsanto Chemical Co.).

(2) Separan 2610 (Dow Chemical Co.).

Specimen

4. For concrete of unknown cement content, a representative specimen of approximately 2 kg, weighed to the nearest 1.0 g, shall be used. A larger specimen may be used if trials show such a size to be workable. Larger specimens will reduce sampling errors. For the laboratory-mixed concrete specified in Section 6(*a*) the entire batch shall weigh 2 kg ± 1.0 g. The specimen shall be placed in a metal container.

Procedure

5. (*a*) Using an auxiliary quantity of concrete secured from the same source as the representative specimen specified in Section 4, determine the weight per cubic foot of the concrete in accordance with the Method of Test for Weight per Cubic Foot, Yield, and Air Content (Gravimetric) of Concrete (ASTM Designation: C 138).[3] For laboratory-mixed concrete, the size of the batch prepared for the unit-weight test shall be large enough to yield the required quantity of concrete as specified in Method C 138.

(*b*) Transfer a portion of the specimen with the No. 0 scoop to the wire cloth basket held in a 3000-ml beaker approximately three-fourths full of water containing about 1 g of Separan 2610 and 1 or 2 ml of Santomerse S. Move the basket and its contents up and down in the beaker and stir with the scoop to insure the passage of all of the fine material through the basket. Discard the contents of the basket and repeat the process with successive portions of the specimen until it has all

[1] W. G. Hime and R. A. Willis, "A Method for the Determination of the Cement Content of Plastic Concrete," ASTM BULLETIN, No. 209, Oct., 1955, p. 37. (TP 191).

[2] 1958 Book of ASTM Standards, Part 4, p. 1256.

[3] 1958 Book of ASTM Standards, Part 4, p. 726.

been treated. Remove traces of the specimen from the metal container and scoop by washing and brushing. Remove the wire cloth basket from the beaker.

(c) Allow the fine material to settle in the beaker for about 5 min. Carefully decant or siphon off the excess water. Transfer the settled material to the skillet with the aid of a brush, using small portions of water as a rinse as may be necessary.

(d) Place the skillet on the hot plate burner and regulate the heat so that the water is quickly but not violently boiled away. After the free water has boiled away, break up lumps with the stirrer, and heat at full heat until the material appears quite dry, continuing to stir and breaking up lumps meanwhile. Heat for an additional 15 min after the material appears dry. Allow the skillet to cool a few minutes, then completely transfer the dried material with the aid of a brush to a weighing pan. Guard against loss through spilling by placing a large piece of glazed paper under the weighing pan. Weigh the dried material to the nearest 0.1 g.

(e) Weigh two 20-g specimens of the fine material onto a piece of glazed paper. Remove lumps by crushing with the blade of the spatula. Place each specimen in a centrifuge tube. Fill the tubes to the 40-ml mark with the heavy liquid mixture specified in Section 3(a). Stir with metal rod to loosen all the cement from the walls of the tube.

(f) Place the tubes in the centrifuge cups and centrifuge at an RCF of about 190 for three min. Stir the top layer with the metal rod and centrifuge again for 4 min at an RCF of about 525. Record the volume of the cement (lower) layer to the nearest $\frac{1}{4}$ ml for future reference.

(g) After centrifuging the specimen, remove the sand layer and the separating liquid by transferring them into a beaker, being careful not to disturb the cement layer. Remove any cement particles from the portion in the beaker by the following washing operation: Pour about 25 ml of acetone into the beaker; stir thoroughly; allow particles to settle during a period of 10 to 20 sec; decant the liquid. Repeat this operation for a total of three washings. Place the beaker on an asbestos pad resting on a hot plate or in the skillet. Heat gently a few minutes until the sand appears dry. Transfer to a tared paper and weigh. The weight of the cement is the difference between the total weight of centrifuge specimen (20 g) and the weight of the sand.

Preparation of Calibration Curve

6. (a) *Gravimetric*

(1) A calibration curve shall be constructed as follows: Prepare two or more batches of concrete for each of several mixtures which have cement contents bracketing the range to be studied. Use the same aggregate as is to be used in the unknowns. Proceed with the determinations as in Section 5. A new calibration curve shall be prepared whenever the aggregate is changed.

(2) Calculate the cement content of the known batches as follows:

Cement content, bags per cu yd

$$= \frac{W_2 \times W_3 \times \gamma}{W_1} \times 0.01436$$

where:

W_1 = weight of specimen of concrete, g,
W_2 = weight of dry material passing No. 30 sieve, g,
W_3 = weight of cement in one centrifuge tube, g, and
γ = unit weight of concrete, lb per cu ft.

(3) Plot the calculated cement contents against the actual cement contents.

(4) Calculate the cement content of the unknown specimen in a similar manner and plot its calculated cement content on the curve developed from the known mixtures. Read the actual cement content.

NOTE 3.—In some instances it may be feasible or sufficient to use a value for the weight of a cubic foot of concrete based upon past experience, and to eliminate the calibration procedure by assuming the calculated cement content to be approximately equal to the actual cement content. Uniformity control on large projects and mixer efficiency tests may be in this class.

(b) *Volumetric*

(1) Under some conditions the cement content may be determined by the volumetric method. For this procedure calculate volume factors as follows:

$$\text{Volume Factor} = \frac{W_2 \times V}{W_1 \times 20}$$

where:

V = volume of cement in one centrifuge tube, ml.

(2) Plot the volume factors of the known batches from Section 6 (a) against the known cement contents. Using the equivalent volume of an unknown specimen read from the curve the corresponding cement content.

(3) A new calibration curve shall be prepared whenever the cement fineness or specific gravity or the type of aggregate changes.

Report

7. Values for cement content shall be reported in bags per cubic yard of concrete to the nearest 1/10 bag.

Accuracy

8. The cement content of the specimen when determined by the procedures described may be expected to be accurate to within ±¼ bag per cubic yard for the gravimetric method using the calibration curve and ±½ bag per cubic yard for the volumetric method (Note 4).

NOTE 4.—Accuracy of the sort described has been obtained uniformly with specimens of concrete mixtures containing portland cement as the only cementitious material. When the smaller size fractions of the fine aggregate include appreciable quantities of material having a specific gravity greater than 3.0 or when finely divided materials other than portland cement are contained in the concrete, caution should be exercised.

Process-Media Test Sites Needed for Corrosion Studies

THE HIGH ALLOYS Committee of the Welding Research Council started extensive field corrosion tests in 1957 to determine what industrial process media cause intergranular attack of austenitic stainless steels. Several hundred corrosion test racks containing welded and unwelded specimens with a variety of heat treatments were prepared. Two series of test racks are being used. One contains molybdenum-bearing alloys such as types 316, 317, the other contains molybdenum-free alloys such as types 304, 310. Data from some of the 10,000 specimens prepared for this program have been received. However, many specimens still remain to be exposed.

This program should help to define the types of media that cause intergranular corrosion. Results will also be used to check the boiling 65 per cent nitric acid test for predicting intergranular corrosion susceptibility.

The committee is now searching for many additional exposure sites in chemical plants. Specifically, immersion in media which have produced intergranular failure of stainless steel components is most desirable. Those interested in participating in this program are invited to submit a description of the exposure site to **R. M. Fuller, International Nickel Co., Inc., 67 Wall St., New York 5, N. Y.** Specific process details are unnecessary, but a description of solution composition and the local exposure conditions will be needed. Upon completion of the exposures, each cooperating group will receive a detailed evaluation of the corrosion test results.

Industry Recommends New ASTM Committee on Ore Sampling and Analysis

At a June 2 Conference at ASTM Headquarters, 35 representatives of ore companies, independent laboratories, steel producers, and other interested parties unanimously recommended that ASTM form a new committee on ore sampling and analysis. Its task would be to formulate methods of sampling, analysis, and testing of metal-bearing ores and related processing raw materials such as fluxes. A steering committee is being appointed to establish a membership and framework for the new committee for consideration by the ASTM Board of Directors.

In January, twenty companies were asked to advise ASTM of their interest in such a project. The result was the conference of June 2. Impetus was given to the January survey by the work of ISO Technical Committee 65 on Manganese Ores. This committee, of which Russia holds the secretariat, has developed about a dozen test methods for sampling and analyzing manganese ores. In addition, the American Institute of Mining, Metallurgical, and Petroleum Engineers has recommended that ASTM is the proper organization to assume the sponsorship for the American Recommended Practice for Methods for Screen Testing of Ores (ASA No. M 5–32). This standard was heretofore sponsored by AIME.

All those interested in the work of the proposed ASTM committee should get in touch with ASTM Headquarters.

NAS-NRC Committee Formed To Study Materials Research

The National Academy of Sciences-National Research Council has appointed a 14-man Committee on the Scope and Conduct of Materials Research. The committee will study the total materials research needs of the country with relation to the general public welfare to determine how more rapid and effective progress can be made. The survey will include basic and applied research carried on for defense and non-defense purposes in governmental, industrial, academic, and other institutions, and the resources of raw materials, personnel, and facilities. The committee includes Chairman Clyde Williams, Allen V. Astin, Harvey Brooks, A. J. Herzig, A. B. Kinzel, Thomas H. Miller, John D. Morgan, Jr., T. B. Nolan, A. J. Phillips, C. F. Rassweiler, E. D. Reeves, Frederick Seitz, Cyril S. Smith, and David Swan.

ACR Notes

Administrative Committee on Research

Cooperation on Research Problems

By ERLE I. SHOBERT II[1]

Research can be an attitude of mind. This attitude can lead into the blue or it can confine itself to some specific problem or activity. In any case, however, to be productive the research attitude must lead to some physical or mental activity.

The research activities in the ASTM technical committees are seldom basic or fundamental research in the sense that work is done to learn something in a particular field without regard to its use or application. The ASTM research activities are generally aimed at the solution of particular engineering or scientific problems that are related to the business interests of the members of the committees. Thus, the research activities of ASTM as a whole can be considered to be the sum of a great number of specific activities, each of which has the aims of applied research but which also has the essential activity elements of basic or fundamental research.

It is probably safe to say that there are many people working in areas that would be considered basic research who would very much like to have some of the facilities and equipment that are available to some of the technical committees. Conversely, some of the technical committee activities could be made of much more general use and application if the problems of those working in the basic fields were made known. Additional data under different conditions, obtained with facilities now available to the technical committees, might not only advance the basic work in the field but also might put the committee activity on a stronger foundation.

Some of this liaison is now being done in those committees that have good research records. Where committee membership includes working scientists in the fields of the committee activity, the work generally proceeds along fundamental lines. In the case of some large companies, the basic work is being done outside the ASTM technical committees but is available to the committees through their representatives. There are, however, many areas in which engineering tests are being run to prove a method or check a procedure where little thought is given to the related region from a research standpoint. This is an area in which the Administrative Committee on Research could operate.

It is apparent that the research committee cannot itself carry out any specific projects. But it could provide a clearing house in which the people working in related or widely different fields having similar problems might be brought together. As a beginning, the committee might invite questions from anyone concerning the availability of equipment. It could arrange for joint research activities and help to establish and maintain communications between people with equipment and those with research problems.

How can the research committee help you to use the ASTM organization, talents, and facilities to better advantage? To be specific, we could suggest that a general offer be made by the technical committees to the effect that they would cooperate in the fields of their activity with qualified workers. This offer could list the fields in which the facilities of the committee could be useful.

[1] Manager of Research, Stackpole Carbon Co., St. Mary's Pa.

We could also suggest that anyone who thinks that facilities useful to him might be present in a technical committee should express his interest and desire to the Administrative Committee on Research. The committee might then put the organization to work on the problem of finding out where the equipment is located and arranging for cooperation. If there is sufficient interest, it would be possible for the committee to advertise the availability of ASTM facilities to other scientific and technical societies.

These are all possibilities. The ideas expressed will serve a need if the need exists, and if a need does not exist, it cannot be created artificially. The Administrative Committee on Research will welcome any discussion or suggestions that would tell us whether or not a service to facilitate cooperative research arrangements would be useful.

Pacific Area Meeting

(*Continued from page 33*)

Thursday, October 15, 8:30 a.m.—Infrared Absorption

Selected Topic in Infrared Spectroscopy—Kent Wilson, Tufts College

Some of the Problems Facing Chemical Infrared Spectroscopy Today—W. J. Potts, Dow Chemical Co.

Ten Years of Aid to Applied Spectroscopy by Committee E-13—R. J. Robey, Esso Research and Engineering.

Thursday, October 15, 2:30 p.m.—General

The Combination of Techniques in Hydro-Carbon Analysis—N. D. Coggeshall, Gulf Research and Development Co.

Report on Three European Spectroscopy Meetings Attended Early in 1959—R. R. Brattain, Shell Development Co.

Molecular Spectroscopy in the U.S.S.R.—D. G. Rea, California Research Corp.

In addition to the formal sessions there will be the Bay Area Tour to electronic companies on October 13.

Symposium on Methods for Testing Building Constructions, Monday, October 12, 2:30 p.m.

The following paper should be added:

Lateral Shear Tests of a Light Gage Steel Building—J. J. Holstein, Structural Engineer, Los Angeles.

Symposium on Technical Development in the Handling and Utilization of Water and Industrial Water, Thursday, October 15, 8:30 a.m.

The paper by Mr. Gerhard Klein on *Radiological Criteria for Industrial Waters* has been withdrawn and replaced by: *Utilization of Cooling Towers in Conservation and Pollution Control Programs*—J. J. Finnerty, Foster Wheeler Corp.

ASTM Standards Approved as *American Standard* by American Standards Association

STEEL (Approved May 11, 1959)

Specifications for:

Steel for Bridges and Buildings (ASTM A 7–58 T; ASA G24.1–1959)

Billet-Steel Bars for Concrete Reinforcement (ASTM A15–58 T; ASA A50.1–1959)

Mild-to-Medium-Strength Carbon-Steel Castings for General Application (ASTM A 27–58; ASA G50.1–1959)

Cold-Drawn Steel Wire for Concrete Reinforcement (ASTM A 82–58 T; ASA A50.3–1959)

Forged or Rolled Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service (ASTM A 105–58 T; ASA G17.3–1959)

Structural Steel for Locomotives and Cars (ASTM A 113–58; ASA G39.1–1959)

Structural Rivet Steel (ASTM A 141–58; ASA G21.1–1959)

High-Strength Steel Castings for Structural Purposes (ASTM A 148–58; ASA G52.1–1959)

Forged or Rolled Steel Pipe Flanges, Forged Fittings, and Valves and Parts for General Service (ASTM A 181–58 T; ASA G46.1–1959)

Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service (ASTM A 182–58 T; ASA G37.1–1959)

Welded Steel Wire Fabric for Concrete Reinforcement (ASTM A 185–58 T; ASA G45.1–1959)

Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service (ASTM A 194–58 T; ASA G38.1–1959)

COPPER AND COPPER ALLOYS (Approved April 24, 1959)

Specifications for:

Free-Cutting Brass Rod, Bar, and Shapes for Use in Screw Machines (ASTM B 16–58; ASA H8.1–1959)

Seamless Copper Pipe, Standard Sizes (ASTM B 42–58; ASA H26.1–1959)

Seamless Copper Water Tube (ASTM B 88–58; ASA H23.1–1959)

Rolled Copper-Alloy Bearing and Expansion Plates and Sheets for Bridge and Other Structural Uses (ASTM B 100–58; ASA H31.1–1959)

Leaded Red Brass (Hardware Bronze) Rod, Bar, and Shapes (ASTM B 140–58; ASA H33.1–1959)

MANUFACTURED MASONRY UNITS (Approved May 5, 1959)

Specifications for:

Sewer Brick (Made from Clay or Shale) (ASTM C32–58; ASA A100.1–1959)

Building Brick (Solid Masonry Units Made from Clay or Shale) (C 62–58; ASA A98.1–1959)

GYPSUM (Approved May 5, 1959)

Specifications for:

Gypsum Plasters (ASTM C 28–58; ASA A49.3–1959)

Gypsum Wallboard (ASTM C 36–58; ASA A69.1–1959)

MAGNESIUM OXYCHLORIDE CEMENTS (Approved May 5, 1959)

Methods of Test for Ignition Loss and Active Calcium Oxide in Magnesium Oxide for Use in Magnesium Oxychloride Cements (ASTM C 247–57; ASA A88.16–1959)

LINSEED OIL (Approved April 16, 1959)

Specifications for:

Raw Linseed Oil (ASTM D 234–58 T; ASA K34.1–1959)

Boiled Linseed Oil (ASTM D 260–58 T; ASA K35.1–1959)

WOOD (Approved May 5, 1959)

Specifications for Round Timber Piles (ASTM D 25–58; ASA 06.1–1959)

BARE ELECTRICAL CONDUCTORS

Specifications for:

Soft Rectangular and Square Bare Copper Wire for Electrical Conductors (ASTM B 48 – 58; ASA C7.9-1959).

Rope-Lay-Stranded Copper Conductors Having Bunch-Stranded Members for Electrical conductors (ASTM B 172 – 58; ASA C7.12-1959).

Rope-Lay-Stranded Copper Conductors Having Concentric-Stranded Members for Electrical Conductors (ASTM B 173 – 58; ASA C7.13-1959).

Bunch-Stranded Copper Conductors for Electrical Conductors (ASTM B 174 – 58; ASA C7.14-1959).

Concentric-Lay-Stranded Aluminum Conductors, Hard-Drawn, Three-Quarters Hard-Drawn, and, One-Half Hard-Drawn (ASTM B 231 – 58; ASA C7.21-1959).

Concentric-Lay-Stranded Aluminum Conductors, Steel-Reinforced (ACSR) (ASTM B 232 – 58; ASA C7.22-1959).

Copper Bus Bar, Rod and Shapes (ASTM B 187 – 58; ASA C7.25-1959).

Seamless Copper Bus Pipe and Tube (ASTM B 188 – 58; ASA C7.26-1959).

Standard Weight Zinc-Coated (Galvanized) Steel Core Wire for Aluminum Conductors, Steel Reinforced (ACSR) (ASTM B 245 – 58; ASA C7.28-1959).

Zinc-Coated (Galvanized) Steel Core Wire (With Coating Heavier than Standard Weight) for Aluminum Conductors, Steel Reinforced (ACSR) (ASTM B 261 – 58; ASA C7.34-1959).

Method of Test for:

Resistivity of Electrical Conductor Materials (ASTM T 193 – 58; ASA C7.24-1959).

New Tentatives

(*Continued from page 31*)

Dielectric Constant and Dissipation Factor of Expanded Cellular Plastics Used for Electrical Insulation (D 1673 – 59 T)

Frictional Characteristic of Enameled Magnet Wire for Use in Winding Filled Coils (D 1676 – 59 T)

Methods of:

Testing Electrical Grade Polytetrafluorethylene Tubing (D 1675 – 59 T)

Sampling and Testing Untreated Mica Paper Used for Electrical Insulation (D 1677 – 59 T)

Recommended Practice for:

Exposure of Polymeric Materials to High Energy Radiation (Jointly with D-20) (D 1672 – 59 T)

BITUMINOUS MATERIALS FOR ROOFING, WATERPROOFING, AND RELATED BUILDING OR INDUSTRIAL USES (D-8)

Specification for:

Woven Glass Fabrics Saturated with Bituminous Substances for Use in Waterproofing (D 1668 – 59 T)

Methods of:

Preparation of Test Panels for Accelerated and Outdoor Weathering of Bituminous Coatings (D 1669 – 59 T)

Test for Failure Endpoint in Accelerated and Outdoor Weathering of Bituminous Materials (D 1670 – 59 T)

RUBBER AND RUBBER-LIKE MATERIALS (D-11)

Specification for:

Synthetic Rubber Heat- and Moisture-Resisting Insulation for Wire and Cable, 75 C Operation (D 1679 – 59 T)

Methods of:

Testing Automotive Air Conditioning Hose (D 1680 – 59 T)

SOAPS AND OTHER DETERGENTS (D-12)

Method of Test for:

Synthetic Anionic Active Ingredient in Detergents by Cationic Titration Procedure (D 1681 – 59 T)

TEXTILE MATERIALS (D-13)

Method of Test for:

Construction Characteristics of Woven Fabrics (D 39 – 59 T)

Breaking Load and Elongation of Textile Fabrics (D 1682 – 59 T)

Seam Breaking Strength of Woven Textile Fabrics (D 1683 – 59 T)

Recommended Practice for:

Lighting Cotton Classing Rooms for Color Grading (D 1684 – 59 T)

INDUSTRIAL AROMATIC HYDROCARBONS AND RELATED MATERIALS (D-16)

Methods of Test for:

Color of Solid Aromatic Hydrocarbons and Related Materials in the Molten State (Platinum-Cobalt Scale) (D 1686 – 59 T)

Traces of Thiophene in Benzene Using Isatin and Spectrophotometry (D 1685 – 59 T)

INDUSTRIAL WATER (D-19)

Methods of Test for:

Copper in High-Purity Water (D 1688 – 59 T)

Silica in High-Purity Water (D 1689 – 59 T)

Measurement of Gamma Radioactivity of Industrial Water and Industrial Waste Water (D 1690 – 59 T)

Total Chromium in Industrial Water and Industrial Waste Water (D 1687 – 59 T)

Zinc in Industrial Water and Industrial Waste Water (D 1691 – 59 T)

PLASTICS (D-20)

Method of Test for:

Gamma Radiation by Chemical Dosimetry (Jointly with D-9) (D 1671 – 59 T)

Flammability of Plastic Foams and Sheeting (D 1692 – 59 T)

Environmental Stress Cracking of Type I Ethylene Plastics (D 1693 – 59 T)

Recommended Practice for:

Exposure of Polymeric Materials to High Energy Radiation (Jointly with D-9) (D 1672 – 59 T)

Specifications for:

Thermosetting Reinforced Plastic Pipe Thread System (D 1694 – 59 T)

CELLULOSE AND CELLULOSE DERIVATIVES (D-23)

Method of Test for:

Solubility of Cellulose in Sodium Hydroxide (D 1696 – 59 T)

Definitions of Terms:

Relating to Cellulose and Cellulose Derivatives (D 1695 – 59 T)

CASEIN AND SIMILAR PROTEIN MATERIALS (D-25)

Method of:

Sampling Casein and Similar Protein Materials (D 1697 – 59 T)

ELECTRICAL INSULATING LIQUIDS AND GASES (D-27)

Method of Test for:

Sediment and Soluble Sludge in Service-Aged Insulating Oils (D 1698 – 59 T)

METHODS OF TESTING (E-1)

Specifications for:

Gravity-Convection and Forced-Ventilation Laboratory Ovens (E 145 – 59 T)

Method of Test for:

Shear Modulus at Room Temperature (E 143 – 59 T)

Recommended Practice for:

Safe Use of Oxygen Combustion Bombs (E 144 – 59 T)

CHEMICAL ANALYSIS OF METALS (E-3)

Methods for:

Chemical Analysis of Zirconium and Zirconium-Base Alloys (E 146 – 59 T)

NONDESTRUCTIVE TESTING (E-7)

Method for:

Controlling Quality of Radiographic Testing (E 142 – 59 T)

MATERIALS FOR ELECTRON TUBES AND SEMICONDUCTOR DEVICES (F-1)

Specifications for:

Miniature Electron Tube Leads (F 10 – 59 T)

LEATHER (JOINT ALCA-ASTM)

Method of Test for:

Bond Strength of Leather Belting (D 1699 – 59 T)

Standard Glass Spheres for Calibrating Sieves

HIGHER ACCURACY in the calibration of testing sieves can now be achieved with two standard samples of glass spheres available from the National Bureau of Standards. With these standards of certified particle-size distribution, the effective opening of a sieve can be easily measured.

To calibrate any set of sieves, they are assembled in a pile with the sieve containing the largest openings on top. The entire sample of glass spheres is placed on the top sieve. The sieves are then shaken until the rate of passage of the spheres is practically zero, just as in the sieve analysis of an unknown material. The spheres that remain on each sieve are carefully weighed. The effective sieve openings can then be determined from calibration data supplied with the samples.

Sample 1017 contains spheres 50 to 230 μ in diameter, and is used to calibrate sieves U. S. No. 270 through U. S. No. 70. Sample 1018 contains spheres 210 to 980 μ in diameter, and is used to calibrate sieves U. S. No. 70 through U. S. No. 20. Reproducibility is within ± 5 per cent for sample 1017 and ± 2 per cent for sample 1018. Samples can be obtained from the Supply Division, National Bureau of Standards, Washington 25, D. C.

The Interlaboratory Evaluation of Testing Methods

By JOHN MANDEL and T. W. LASHOF

Trained manpower and laboratory facilities can be used more effectively if improvements can be made in interlaboratory evaluation of testing methods. There are probably hundreds of these cooperative programs going on all the time under the aegis of the Society's 80 main technical committees. Too often the report of an interlaboratory program indicates the results are not useful because some variable was not adequately controlled or because there was some flaw in planning the program.

Planning interlaboratory test programs has occupied the attention of most if not all of the technical committees; in fact, two—D-11 on Rubber and D-13 on Textiles—have prepared recommended practices which have been published by ASTM (D 1421 and D 990, 1958 Book of ASTM Standards, Parts 9 and 10).

Committee E-11 on Quality Control of Materials has the assignment to develop a general recommended practice for interlaboratory testing for use by all the committees. It is accordingly quite interested in the present paper, as indicated by the following statement by one who reviewed the paper for the committee:

"This paper gives a very complete treatment of the problem which almost every ASTM committee is constantly trying to solve . . . (it is) a more comprehensive approach to the problem of designing and interpreting interlaboratory studies than has appeared in the literature up to now. Their (the authors') ideas are complex because the problem they are trying to solve is complex."—Ed.

The various sources of variability in test methods are examined, and a new general scheme to account for them is proposed. The assumption is made that systematic differences exist between sets of measurements made by the same observer at different times or on different instruments or by different observers in the same or different laboratories and that these systematic differences are linear functions of the magnitude of the measurements. Hence, the proposed scheme is called "the linear model." The linear model leads to a simple design for round-robin tests but requires a new method of statistical analysis, geared to the practical objectives of a round robin. The design, analysis, and interpretation of a round robin in accordance with the linear model are presented, and the procedure is illustrated in terms of the data obtained in an interlaboratory study of the Bekk smoothness tester for paper. It is believed that this approach will overcome the "frustrations" that are often associated with the interpretation of round-robin test data.

In this paper a new approach is presented for the analysis of interlaboratory studies of test methods. The various sources of variability in test methods are first reexamined and a new general scheme to account for them is proposed. This scheme leads to a simple design for round-robin tests but requires a new method of statistical analysis, geared to the practical objectives of a round robin. The theoretical details are dealt with in a companion paper (1).[1] In the present article, the emphasis is on the application of the new concepts to ASTM committee studies of test methods. The procedure is illustrated in terms of the data obtained in an interlaboratory study of the Bekk smoothness tester for paper.

For much of the discussion in this paper, the consideration of different laboratories is not an absolute requirement. The word "laboratory" is used here to denote a set of measurements obtained under conditions controlled within the set but such that systematic differences may exist from one set to another. For example, different operators within the same laboratory may also show systematic differences. The same may be true for sets of measurements obtained even by the same operator at different times. Since the use of different laboratories, in the usual sense, is likely to result in the greatest number and severity of systematic differences, the practice of conducting interlaboratory round-robin programs for the study of test methods appears entirely justified.

A New Approach: The Linear Model

We will assume that an interlaboratory study of a particular test method has been run in accordance with the schematic diagram shown in Table I; specifically, to each of a laboratories, b materials have been sent for test and each laboratory has run each material n times. Let us suppose that the b materials cover most of the useful range of the test method under study for the type of material examined. The n determinations made by the ith laboratory on the jth material constitute what will be denoted henceforth as the "i,j cell" (see Table I). Our reasons for using this scheme will become apparent as we develop the linear model.

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NOTE—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the authors. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] The boldface numbers in parentheses refer to the list of references appended to this paper.

TABLE I.—INTERLABORATORY STUDY INVOLVING a LABORATORIES, b MATERIALS, AND n REPLICATIONS.

		Materials						
		No. 1	No. 2	No. 3	...	j	...	b
Laboratories	No. 1	--- ---	--- ---	--- ---		--- ---		--- ---
	No. 2	--- ---	--- ---	--- ---		--- ---		--- ---
	No. 3	--- ---	--- ---	--- ---		--- ---		--- ---
	...							
	i	--- --- ---	--- --- ---	--- --- ---		i, j Cell --- --- n ---		--- --- ---
	...							
	a	--- --- ---	--- --- ---	--- --- ---		--- --- ---		--- --- ---
Averages		---	---	---		---		---

In order to present the new basic concepts, we assume that the materials have been arranged in Table I in increasing order of the magnitude of the measurements for each material averaged over all laboratories. Now consider a graph in which the average result obtained by each laboratory for any given material is plotted against the average result of all laboratories for that material. Figure 1 shows such a graph for one laboratory. In this case, the laboratory in question agrees exactly with the average of all laboratories. Such an ideal occurrence is highly unlikely.

It is often assumed that the differences in results obtained by different laboratories are systematic in the sense that a constant systematic difference is observed between two different laboratories. If this were the case, the plot of the various laboratories against the average of all laboratories would consist of a family of parallel straight lines (Fig. 2). The fact is, however, that there exist many test methods for which the lines in question are not parallel but show changes in slope as well as vertical shifts with respect to each other (Fig. 3). Figures 4 (a) and (b), like Fig. 2, show interesting special cases of the general situation shown in Fig. 3. The linear model is based on the assumption that whereas the response lines of the various laboratories are not necessarily identical or even parallel, they nevertheless are straight lines, differing in slope or in intercept or both.

Thus, the linear model constitutes a generalization of the usual model of constant differences between laboratories. It is of course conceivable that the response lines of some of the laboratories will show curvature, requiring a second degree equation or higher to represent them. In practice, however, this situation will arise only if a laboratory is discrepant by an order of magnitude, indicating drastic departures from the prescribed procedure. When the data corresponding to such a laboratory are omitted, the remaining data conform to the linear model. But even if such a laboratory is inadvertently retained, the method of analysis proposed in this paper provides for the detection and elimination of such discrepant data.

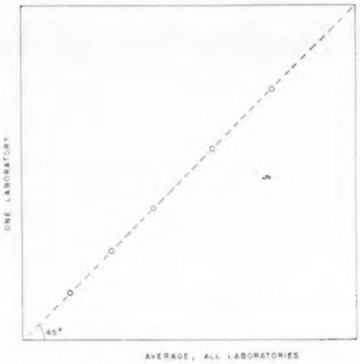


Fig. 1—Data from an ideal laboratory.

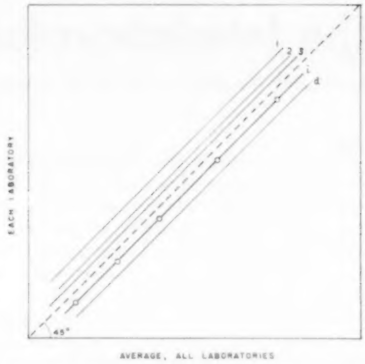


Fig. 2.—Constant systematic differences between laboratories. "Observed" material averages are shown only for the ith laboratory.

Up to this point we have considered only the systematic differences between laboratories. Actually the observed material averages for a laboratory do not fall exactly on the line for that laboratory. This is because of within-laboratory variability. We will distinguish two types of within-laboratory variability. The first type relates to the fluctuations in results obtained on identical specimens, or if this be impossible, on specimens for which the property under study has, as closely as can be achieved, the same value. If this type of fluctuation, which we will call "replication error," ω, was the only type of within-laboratory variability, the observed averages for each laboratory, Fig. 5, could be made to fit the straight line as precisely as desired solely by increasing the number of replications.

The second type of within-laboratory variability, the effect of which cannot be reduced by merely increasing the number of replications, is less obvious. In order to illustrate its nature, let us consider the process of weighing on an analytical balance. Suppose that the weights of two samples, A and B, are to be determined, and suppose that sample A weighs a little over 1 g while sample B weighs slightly more than 5 g, thus requiring the use of two different standard weights in weighing the two samples. It is clear that the relationship between the true weights of samples A and B is known only to the extent in which two standard weights are correctly calibrated with respect to each other. The precision of this relationship cannot be improved by repeated weighings of A and B separately. Thus, consideration of more than a single sample (material) leads to a second type of within-laboratory variability, dependent on the correct relationship of the various scales, weights, or other items involved in measuring quantities of different magnitudes. This "scale-type" error can also arise from the presence of interfering substances, as in chemical analysis, or interfering properties, as in a physical method. For indeed, apart from a possible effect on the replication error, the presence of an interfering property may tend to either raise or lower the measured value, just as an improperly calibrated weight does. If different laboratories respond differently to such interfering factors, their apparent effect, in an interlaboratory study of the type here considered, will be an additional scatter of the experimental points about the straight lines corresponding to the various laboratories. This additional scatter or scale-type error, which we will refer to here as λ-variability,[2] cannot be reduced by merely increasing the number of replications.

The linear model, which we have developed here, is illustrated in Fig. 5. This figure shows a much exaggerated view of the linear systematic differences between laboratories and the within-laboratory variability of one of the laboratories. A more complete discussion of the assumptions underlying this model is given in reference (1).

[2] In reference (1) the interfering factors themselves are called "I-factors." The λ-variability is then due both to scale-type errors and to the differential response of the laboratories to the I-factors.

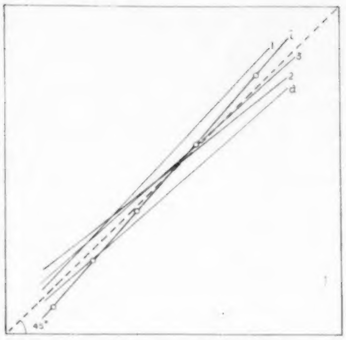
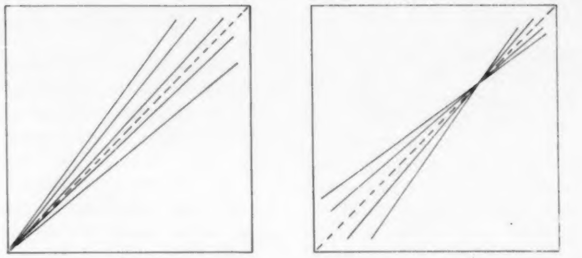


Fig. 3.—Linear systematic differences between laboratories.



(a) (b)

Fig. 4—Special cases of the general case shown in Fig. 3.

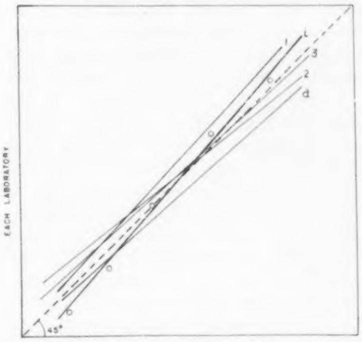


Fig. 5.—The linear model of an interlaboratory study. The observed values, including within laboratory error, are shown for the *i*th laboratory.

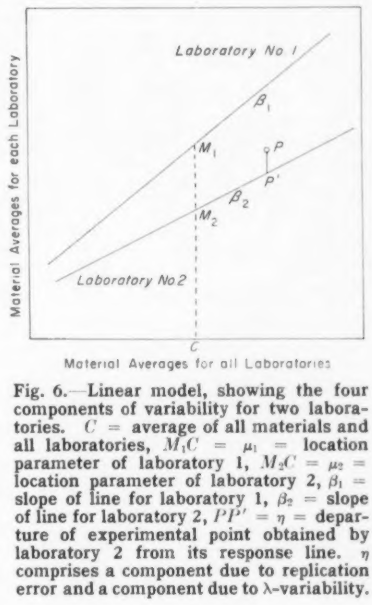


Fig. 6.—Linear model, showing the four components of variability for two laboratories. C = average of all materials and all laboratories, $M_1C = \mu_1$ = location parameter of laboratory 1, $M_2C = \mu_2$ = location parameter of laboratory 2, β_1 = slope of line for laboratory 1, β_2 = slope of line for laboratory 2, $PP' = \eta$ = departure of experimental point obtained by laboratory 2 from its response line. η comprises a component due to replication error and a component due to λ-variability.

The Design of an Interlaboratory Round Robin

The linear model developed in the preceding section is based on the interlaboratory study schematically shown in Table I. This is the design which we propose. We must now fill in the details of the design.

First it is necessary to describe precisely the test method to be studied. It is surprising how vague even some widely used test methods are as regards essential details of procedure. These details should be completed through committee discussion, a survey of the literature, and experimental work within one laboratory. The draft of the detailed procedure should be circulated among all participating laboratories possibly with trial specimens, for comment and clarification.

The next question is how many and what materials are to be included in the round robin? This depends on how wide a range of materials, both as to type of material and magnitude of the property being tested, is to be covered by the test method. Also it depends on whether the instrument is a single-scale instrument or a multiple-scale instrument. Experience shows that it is desirable to use no less than five materials per scale, the five materials covering the useful range of the scale. If the study includes materials of widely different types, more materials will be needed, because in such cases, the random error will be substantially increased through the effect of λ-variability.

How many laboratories should be included? Here, a limiting factor is the amount of work involved in preparing the samples for distribution to the participating laboratories and the increase in sampling variability due to the larger amount of material required. Subject to these limitations, the number of laboratories should be as large as practicable, say, not less than 10 and preferably 20 or 30. Assurance should be obtained that each participating laboratory is properly equipped to follow all the details of procedure, and willing to assign the work to competent personnel.

The final question to be answered before the preparation of specimens is begun is how many tests are to be run by each laboratory for each material. It is suggested that if the standard (or usual) test procedure calls for r replications, the round robin should call for an integral multiple of this number. Thus, $n = mr$ where m is an integer, preferably not less than 4. The number of replications should be as large as practicable consistent with economic considerations of time and material and statistical considerations as to the homogeneity of each material.

In making the assignments of the specimens of each material to the participating laboratories, they should be completely randomized. Of course, wherever feasible, the total portion of material used should be either selected for maximum homogeneity or, if possible, subjected to a thorough mixing prior to the assignment of specimens to the various laboratories. Any attempt to assign the specimens in such a way as to minimize within-laboratory variability at the expense of between-laboratory variability or *vice-versa* will only complicate the analysis. Experience has shown that the most satisfactory method of assignment of specimens is indeed the completely random one.

All specimens should be properly coded in such a way that only the person or persons conducting the round robin can identify the specimens. Ideally, the specimens should be thoroughly mixed so that they will be tested in random order. While this may be feasible in some cases, it may result, in many cases, in an excessive manipulation of the equipment. It is suggested, that in such cases the n specimens assigned to a given laboratory, for each material, be divided into groups such that the specimens within each group will be tested consecutively, the groups themselves being tested in a random order. For example, if 12 specimens of each of 10 materials are tested by each laboratory, one might divide the 12 specimens into 4 groups of 3 each. Each laboratory would then run the 40 groups in random order, each group consisting of 3 replicates run consecutively.

Analysis of the Data

The purpose of the analysis is the segregation of the total error into components in accordance with the sources discussed above. Thus, we will obtain: (1) A component due to replication error; (2) a component due to λ-variability; and (3) a component due to between-laboratory variability.

In accordance with the previous discussion, the third source is expressed in terms of differences between the "response-lines" for the various laboratories. Since a straight line is determined by two parameters, the component due to between-laboratory variability will comprise two terms, corresponding to the variability of the response lines both in location and in slope. Figure 6 shows the four components of variability for two laboratories in graphical form. Each line is characterized by its location parameter, μ_i, chosen as the ordinate of the centroid and by its slope, β_i. The departure of an experimental point from the corresponding response line is composed of two component parts—the replication error and λ variability.

Analysis of the data is considered in six steps:

Step 1.—Before proceeding to the evaluation of the components of variability, it is necessary to examine the relation between replication error and the magnitude of the measurement. Table II, which relates to the Bekk smoothness data used as illustration in this paper, shows the necessity of this preliminary step. There are 14 laboratories and 14 materials, making a total of 196 cells. For each cell, the average (top figure) and the standard deviation (bottom figure) of 8 replicate measurements are given. It is quite evident that the standard deviation increases with the average. Whenever this occurs, the data are transformed into a different scale (generally of a logarithmic type) before proceeding to the subsequent steps in the analysis of the data. In this paper, we will denote values expressed in the orginal scale by the symbol y and values expressed in transformed scale by z. As a result of the transformation, the replication error ω is also transformed, and the standard deviation of the transformed replication error, which we will denote by ϵ, becomes uniform for all cells.

The formulas for the scale transformation as well as for all subsequent steps of the analysis are contained in the Appendix, in order to preserve continuity of presentation in the body of the paper.

From this point on, it will be assumed that if step 1 has indicated the need for a transformation of scale, such a transformation has been carried out on all cell averages, and that all subsequent calculations, up to and including step 5, are performed on these transformed cell averages.

If no transformation is required, all subsequent calculations are carried out on the original cell averages.

Table III(a) is a schematic representation of the cell averages expressed in the transformed scale, and of their row and column averages μ_i and x_j. The over-all average of all z_{ij} is denoted $\bar{x}$. The table also shows how the various parameters discussed so far and in the following steps are related by means of the equations underlying the linear

TABLE II.—BEKK SMOOTHNESS, SHOWING AVERAGES AND STANDARD DEVIATIONS IN EACH CELL.
(The column averages of these quantities are also shown. Top figure of each pair is average, bottom is standard deviation.[a])

Laboratories	Materials													
	No. 2	No. 10	No. 3	No. 4	No. 9	No. 12	No. 13	No. 5	No. 1	No. 7	No. 8	No. 6	No. 11	No. 14
No. 1....	6.375 1.14	6.750 0.556	12.14 1.55	14.43 1.59	14.44 2.37	18.58 2.46	41.98 9.25	45.71 5.70	86.75 5.99	110.4 20.1	154.2 8.83	143.7 24.7	164.8 17.3	191.4 17.8
No. 2....	5.600 0.807	6.375 1.26	13.06 2.19	14.90 1.34	15.20 1.15	18.14 1.94	41.51 4.28	44.56 5.33	88.68 13.7	102.7 25.2	154.2 14.8	160.1 34.8	170.6 14.8	198.2 16.1
No. 3....	5.250 0.754	5.350 1.39	11.95 6.23	13.70 1.33	13.43 1.53	15.10 4.31	37.90 7.46	43.55 4.74	78.65 11.2	114.9 23.2	137.3 7.49	151.2 25.3	178.1 13.2	173.5 23.7
No. 4....	4.463 0.933	5.550 0.256	10.33 1.50	11.41 0.786	12.21 0.673	15.73 1.25	32.85 5.68	33.14 2.73	64.81 10.3	76.30 5.13	106.9 8.90	122.5 19.0	124.6 10.6	124.2 20.1
No. 5....	4.013 0.681	5.875 0.167	11.73 1.94	13.41 1.04	12.70 1.61	16.16 1.54	40.63 8.51	41.68 2.30	91.28 18.5	100.4 17.0	167.0 14.7	207.1 34.7	207.0 25.1	201.0 28.0
No. 6....	4.025 0.517	4.728 0.092	9.225 1.60	9.875 0.883	10.43 0.957	13.09 0.645	26.45 5.19	29.51 1.27	57.74 2.59	54.88 8.53	82.75 7.32	96.13 16.8	101.8 15.0	102.4 16.8
No. 7....	4.363 0.709	4.674 0.301	10.53 1.75	11.55 1.31	13.79 1.48	14.59 1.70	32.93 4.61	41.19 4.26	78.44 10.2	99.41 17.0	129.9 8.75	179.3 29.7	173.7 11.4	173.6 24.3
No. 8....	4.125 0.641	5.250 0.463	9.625 1.85	11.63 1.41	14.25 1.91	15.38 1.19	36.50 4.41	37.50 4.44	81.88 10.8	99.75 15.7	150.9 16.2	161.0 24.6	166.4 14.3	182.5 27.9
No. 9....	4.500 0.535	5.875 0.354	11.25 1.04	12.63 0.744	13.00 1.51	15.38 1.41	35.63 7.13	40.38 4.14	80.63 8.63	112.4 17.9	155.3 12.6	165.6 15.4	186.3 13.8	205.6 19.6
No. 10....	3.750 0.707	4.375 0.518	9.750 1.39	11.25 0.707	11.25 1.58	13.75 1.28	31.00 7.75	31.88 4.67	65.13 5.77	90.13 19.7	126.0 14.9	139.8 23.4	154.8 12.9	162.3 17.0
No. 11....	4.450 0.737	6.163 0.457	13.01 1.88	13.75 0.750	15.09 1.93	17.01 1.81	34.98 8.04	44.08 4.52	90.11 9.88	105.3 18.8	148.1 13.5	187.0 10.4	198.7 20.2	210.9 37.9
No. 12....	4.425 0.623	5.588 0.954	12.75 1.66	13.35 1.50	14.66 2.67	17.08 2.10	43.00 5.22	47.49 7.41	91.99 14.6	115.1 36.9	172.4 22.8	201.5 31.5	213.6 11.0	217.7 28.4
No. 13....	3.975 0.434	4.738 0.250	9.925 1.51	11.70 1.80	11.25 1.43	14.74 0.955	35.58 4.61	37.23 3.17	78.96 9.74	91.88 1.68	131.8 16.6	150.1 25.0	171.2 20.2	186.2 20.3
No. 14....	3.550 0.460	4.288 0.203	9.250 1.26	11.56 1.32	12.50 1.11	15.10 1.31	37.91 8.38	37.55 3.51	75.80 9.18	95.85 18.1	129.2 9.61	149.4 15.2	172.8 14.8	174.9 15.2
Average ..	4.490 0.691	5.399 0.516	11.04 1.954	12.51 1.179	13.16 1.565	15.70 1.707	36.35 6.466	39.68 4.156	79.35 10.08	97.81 17.50	139.0 12.64	158.2 23.61	170.3 15.33	178.9 22.36

[a] The Bekk smoothness data in this paper are taken from an interlaboratory study of air-leak smoothness testers conducted by a TAPPI joint Graphic Arts and Paper Testing task group.

TABLE III(a).—NOTATION FOR TRANSFORMED DATA.[a]

[a] z_{ij} = cell average, μ_i = row average, x_j = column average, and $\bar{x}$ = grand average. The basic equation for the linear model is $z_{ij} = \mu_i + \beta_i(x_j - \bar{x}) + \eta_{ij}$, where the slope β_i is further broken down according to $\beta_i = \alpha(\mu_i - \bar{x}) + \delta_i$; and the error term η_{ij} according to $\eta_{ij} = \lambda_{ij} + \sum_{k=1}^{n} \epsilon_{ijk}/n$.

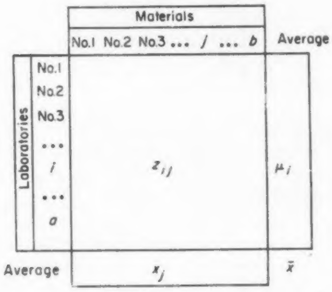


TABLE IV.—BEKK SMOOTHNESS, SHOWING ESTIMATES OF THE PARAMETERS OF THE STRAIGHT LINES CORRESPONDING TO THE VARIOUS LABORATORIES.

Laboratory	β[a]	μ	$V(\eta)$
No. 1	0.9[illegible]2	1601	1049
No. 2	0.962	1602	207
No. 3	0.986	1568	952
No. 4	0.912	1485	308
No. 5	1.057	1588	941
No. 6	0.883	1406	605
No. 7	1.028	1541	852
No. 8	1.028	1546	587
No. 9	1.028	1570	534
No. 10	1.020	1489	364
No. 11	1.016	1595	826
No. 12	1.055	1612	205
No. 13	1.036	1525	235
No. 14	1.048	1519	685
Average	1.000	1546	596

[a] β = slope, μ = ordinate of centroid, $V(\eta)$ = variance (fit) of points to straight line.

TABLE V(a).—ANALYSIS OF VARIANCE.

Sources of Variation	Degrees of Freedom	Sums of Squares	Mean Squares
Laboratories	$a - 1$	S_L	M_L
Materials	$b - 1$	S_M	M_M
Interaction (Laboratory × Material)	$(a - 1) \times (b - 1)$	S_{LM}	M_{LM}

TABLE V(b).—BEKK SMOOTHNESS—ANALYSIS OF VARIANCE.

Sources of Variation	Degrees of Freedom	Sums of Squares	Mean Squares
Laboratories	13	607 616	46 740
Materials	13	59 861 632	4604 741
Interaction	169	260 919	1 544

TABLE III(b).—BEKK SMOOTHNESS, SHOWING CELL, ROW, AND COLUMN AVERAGES AFTER THE DATA HAVE BEEN TRANSFORMED TO EQUALIZE THE WITHIN-CELL VARIANCES.
(The standard error of any value in the table is 19.7.)

Laboratories	Materials														Average
	No. 2	No. 10	No. 3	No. 4	No. 9	No. 12	No. 13	No. 5	No. 1	No. 7	No. 8	No. 6	No. 11	No. 14	
No. 1	804	829	1084	1159	1160	1269	1623	1660	1938	2043	2188	2157	2217	2282	1601
No. 2	748	804	1116	1173	1182	1259	1618	1649	1948	2012	2188	2204	2232	2297	1602
No. 3	720	728	1077	1137	1128	1179	1579	1639	1896	2060	2138	2180	2251	2239	1568
No. 4	650	744	1014	1057	1087	1197	1517	1520	1812	1882	2029	2088	2096	2094	1485
No. 5	603	769	1069	1127	1104	1208	1609	1620	1960	2002	2223	2316	2316	2301	1588
No. 6	605	675	965	995	1018	1117	1422	1470	1762	1739	1918	1983	2008	2010	1406
No. 7	640	670	1022	1063	1140	1164	1518	1615	1894	1997	2114	2256	2240	2240	1541
No. 8	615	720	983	1066	1154	1187	1562	1574	1913	1999	2179	2207	2221	2261	1546
No. 9	653	769	1051	1101	1114	1187	1552	1606	1906	2051	2191	2219	2270	2313	1570
No. 10	574	641	989	1051	1051	1138	1491	1503	1814	1955	2100	2146	2190	2210	1489
No. 11	648	790	1114	1138	1179	1231	1544	1644	1955	2022	2171	2272	2298	2324	1595
No. 12	646	747	1106	1126	1166	1232	1634	1677	1964	2061	2237	2304	2330	2338	1612
No. 13	599	676	997	1068	1051	1168	1551	1571	1897	1963	2120	2179	2234	2270	1525
No. 14	550	632	966	1063	1097	1179	1579	1575	1880	1982	2113	2174	2238	2243	1519
Average	647	728	1039	1095	1116	1194	1557	1594	1896	1983	2136	2192	2224	2244	1546

model. Table III(b) is the corresponding table for the Bekk smoothness data.

Step 2.—The second step in the analysis of the data consists in locating the straight line corresponding to each laboratory in the linear model. Mathematically, a straight line is defined by two parameters. Statistically, however, a third quantity is of interest, namely, the variance characterizing the discrepancies of the experimental points from the line representing them. Thus, for each line three quantities are of interest: the ordinate of the center of gravity of the line, μ; the slope β; and the variance $V(\eta)$, where η is the departure of an experimental point from the corresponding line. These values are computed by the usual least squares formulas for linear regression: the z values for the ith laboratory constitute the dependent variable and the averages of all laboratories for the various samples (in the transformed scale) constitute the independent variable.[3] All formulas are given in the Appendix. Table IV shows the estimated values of μ, β, and $V(\eta)$ for each laboratory calculated from the data of Table III(b). Note that the average of the calculated β values is, as it should be, equal to unity. The average of the μ values should be $\bar{x}$, the grand average of all values. The average of the calculated $V(\eta)$ values is an unbiased estimate of $V(\eta)$ which is needed in the next two steps.

Step 3.—At this point of the analysis, the values of $V(\eta)$ for the various laboratories should be carefully examined. If any one of these values is excessively large in comparison with the others, it is advisable to calculate the individual estimates of η, that is, the "residuals" from the regression line for the laboratory in question, in order to detect the possible presence of a completely discrepant individual point. A plot may sometimes be useful in detecting the cause of an abnormally large estimate of $V(\eta)$. In some cases, the laboratory in question may have to be omitted from the computations and a search instituted for the physical reasons of its abnormal behavior. If it is decided to omit the data for such a laboratory, the values of β, and $V(\eta)$ must be recalculated for all other laboratories.

The values of μ for the remaining laboratories are, of course, unaffected by the omission, but the over-all average $\bar{x}$ must be recomputed (see Table III(a)).

When the estimates of $V(\eta)$ for the individual laboratories are considered to be in satisfactory agreement, they are averaged to give an over-all estimate of $V(\eta)$. This parameter estimates the scatter of the experimental points corresponding to any given laboratory about the line for that laboratory. Part of the variability expressed by $V(\eta)$ is due to the replication error ϵ, while the remainder is precisely the λ-variability discussed in an earlier section. The partition of $V(\eta)$ into these two parts is shown in the Appendix.

Step 4.—The fourth step in the analysis of the data consists in a segregation of between-laboratory variability into two parts: the variability of the location parameter, μ, and the variability of the slope β. First, an ordinary analysis of variance is made, as indicated in Table V(a) and illustrated for

[3] For most purposes this procedure, which is really an approximation, will be entirely satisfactory. The reader who is interested in a more rigorous analysis will find the pertinent formulas in reference (**1**).

the Bekk smoothness data in Table V(b). The two variances $V(\mu)$ and $V(\beta)$ are derived from the mean-squares by formulas given in the Appendix.

The slopes and centroids of the laboratory lines may be correlated. Complete correlation occurs when all of the lines pass through a single point as in Fig. 4. In general, the correlation is not complete and $V(\beta)$ is composed of two parts, the first accounting for the correlation between μ and β, and the second for that portion of the variability of β that is unrelated to μ. This second part is denoted $V(\delta)$. The appendix gives the appropriate formulas for the partition of $V(\beta)$ into these two parts.

Step 5.—In this step the various sources of variability are considered simultaneously and the relative contribution of each source to the total variance is evaluated. In the case of nonparallel response lines for the various laboratories, the laboratory-to-laboratory component will differ with the value of the measurement (see Figs. 3 and 4). Therefore, the breakdown of variability must be evaluated separately for each region in the range over which the method is studied. In practice, it will suffice to select a few values, perhaps six in number, such that they are approximately evenly spaced over the entire range of z-values.

The components of interest are: the replication error, ϵ; the λ-variability; and the between-laboratory variability characterized by μ and β. Actually, since β is partly related to μ, the between-laboratory variability is expressible in terms of μ and δ, the latter being that part of β that is independent of μ. Therefore, a table is prepared showing, for the few selected values of z, the relative contributions of ϵ, λ, μ, and δ to the total variance of z. The first six columns of Table VI illustrate this step in the analysis of the Bekk smoothness data. Formulas for this step are given in the Appendix.

Step 6.—Finally, in case a transformation of scale was required, the total variance $V(z)$, or rather its square root, the standard deviation of z, is converted back into the original scale, giving σ_y. It is also useful, in this case, to convert the values of z chosen for the calculations in Table VI, into corresponding y values, that is, into the original scale. The last two columns in Table VI illustrate this step for the Bekk smoothness data.

Interpretation of the Analysis

In interpreting the results of the analysis, the points of major interest are (a) the relative importance of the various sources of error, (b) the steps re-

TABLE VI.—BEKK SMOOTHNESS, SHOWING RELATIVE IMPORTANCE OF THE VARIOUS SOURCES OF VARIABILITY.

z-Scale		Sources of Variability				y-Scale	
Average z	Total Variance $V(z)$	Within Laboratory		Between Laboratory		Average, sec y	Standard Deviation σ_y
		$\frac{V(\epsilon)}{V(z)}$	$\frac{V(\lambda)}{V(z)}$	$\frac{[1 + \alpha(z - \bar{z})]^2 V(\mu)}{V(z)}$	$\frac{(z - \bar{z})^2 V(\delta)}{V(z)}$		
2224.....	10 011	0.31	0.02	0.57	0.10	170.3	39.2
1896.....	8 028	0.38	0.03	0.56	0.03	79.4	16.4
1557.....	6 636	0.47	0.03	0.50	0.00	36.4	6.8
1116.....	5 814	0.53	0.04	0.36	0.07	13.16	2.3
647.....	6 169	0.50	0.03	0.18	0.28	4.49	0.81

quired to improve precision, if necessary, and (c) the need for standard samples. For these purposes, the following procedure is recommended.

1. Compare $V(\lambda)$ and $V(\epsilon)$: the relation between these two quantities will reveal how much can be expected from mere replication of measurements. If $V(\lambda)$ is large with respect to $V(\epsilon)$, replication is generally a waste of time. Even if $V(\lambda)$ is smaller than $V(\epsilon)$, replication is useful only to the point of making $V(\epsilon)/n$ small with respect to $V(\lambda)$. Thus, in the case of the Bekk smoothness data (Table VI) the replication error exceeding $V(\lambda)$ by a factor of ten, approximately, an effective increase in precision will result from ten replications. But a number of replications considerably larger than ten would be wasteful since the limiting factor, at that point, is $V(\lambda)$ which is unaffected by replication.

2. Study the table of values of β and μ for the various laboratories. Occasionally, a single laboratory (or a small group of laboratories) is discrepant in one or both these parameters, while all others are in close agreement. An investigation of the causes of such discrepancies is then indicated, and the analysis of variance carried out by omitting the discrepant laboratory (or laboratories) may be more meaningful than that based on its inclusion.

In Table IV, two of the laboratories show much smaller values for both β and μ than the other laboratories. These two were foreign laboratories where the standard relative humidity is appreciably higher than in the American laboratories. However, even this appreciable difference in procedure does not require the omission of these laboratories when the analysis is made using the linear model.

3. Compare the total between-laboratory variability for various values of z with the within-laboratory variability (Table VI) keeping in mind that the effect of $V(\epsilon)$ will depend on the number of replications which is called for by the standard method. If the total between-laboratory variability is small compared with the within-laboratory variability throughout the table, all of the laboratories are essentially in agreement and only refinement of the procedure to reduce $V(\lambda)$ can improve the precision of the method.

If $V(\lambda)$ is so large that the method is not sufficiently precise to be useful, the possible cause of a large $V(\lambda)$ should be investigated. Perhaps types of materials were included in the round robin for which the method was not designed. Perhaps the method as written fails to call for the control of important interfering conditions or fails to correct for significant interfering properties.

If the between-laboratory variability is not negligible, examine its two terms separately. If the term in $V(\delta)$ may be neglected, the lines will form a simple pattern: they will either converge to a point (or a small region) or be, for all practical purposes, parallel. In either case, the calibration of the method at a single point other than the point of convergence will suffice to obtain the maximum possible agreement among the laboratories. On the other hand, if the term in $V(\delta)$ becomes appreciable anywhere in the table, the lines for the different laboratories will tend to criss-cross at random and the method will require calibration at two points. (This is the situation for the Bekk smoothness data of Table VI.) There is one exception: if the term in $V(\mu)$ is negligible but not the term in $V(\delta)$, the lines just happen to converge at the centroid, and calibration will be required at a single point as far away from the centroid as is practical.

In general, the term in $V(\mu)$ will not be negligible throughout the table. If the variation in this term is small, the place of the required calibration point or points in the range of the measured quantity is immaterial, except that when two points are required they should be located as far apart as practical. If the variation in the $V(\mu)$ term is appreciable (as for the Bekk smoothness data shown in Table VI), the lines will partially or completely converge and the calibration point or points should be located to avoid the area of convergence.

In summary, if between-laboratory variability is greater than within-lab-

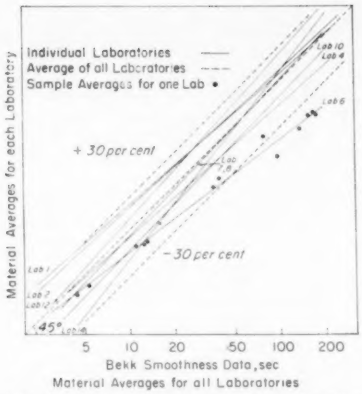


Fig. 7.—Bekk smoothness data, showing nonparallelism of the laboratory lines. The scale on both coordinate axes is logarithmic, but the vertical deviation of each point from the 45 deg line has been doubled in order to clearly show the differences between the laboratories. The broken lines correspond to deviations of plus or minus 30 per cent from the average (45 deg line). A few of the laboratories close to the 45 deg line have been omitted for clarity. The material averages are shown for one laboratory for which the fit of the points to the line is typical.

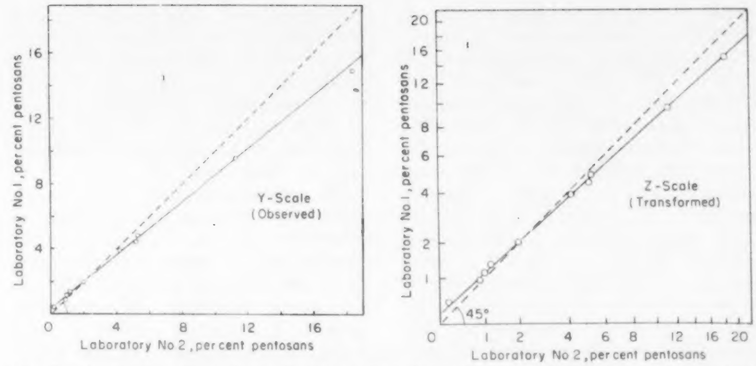


Fig. 8—Pentosans, by orcinol, showing comparison for two laboratories. The slope of the line is distinctly different from unity in either scale. Therefore, these two laboratories will show nonparallelism in a graph of the type shown in Fig. 3. (These data are from an interlaboratory study of orcinol, aniline acetate and bromination methods for the determination of pentosans in pulps. This study was under the direction of a joint ACS-ASTM-TAPPI-ICCA task group.)

oratory variability and greater than can be tolerated for practical application of the method, the method must have better standardization. This can be done by using one or two standard samples to calibrate the method at appropriately chosen values of the measured quantity.

Comparison with Other Models

In the previous sections we have developed the linear model for the measuring process and discussed the design, analysis, and interpretation of an interlaboratory study in accordance with this model. The question naturally arises as to how this model compares with the models underlying the more conventional statistical designs and analyses.

The simplest interlaboratory study is one in which a random sample of a particular material is sent to each of two or more laboratories and they are asked to report the value of some property of the material. If the laboratories turn in values that are in satisfactory agreement with each other, the methods used by the laboratories are considered to be satisfactory and everyone is happy. If the values do not agree within the hoped-for limits, this simple study is unable to furnish even the slightest hint as to the cause or causes of the unsatisfactory results.

Had each laboratory been asked to make duplicate or replicate measurements on the sample it received, the differences found between laboratories might be found to be entirely accounted for by the inability of each laboratory to duplicate its own results. While the simple study fails to distinguish between the variability within and between laboratories, the second type is generally interpreted in terms of a model that allows for random variability between laboratories beyond the within-laboratory fluctuation. This is the model which, with some ramifications, is very frequently used in interlaboratory studies of test methods.

A typical ramification is to have several analysts in each laboratory. Also each analyst may repeat the test on each of several days. The result is an hierarchical or nested design (**2**, p. 884f) which provides information on the relative importance of the various possible sources of within-laboratory variability. Very often each analyst is also asked to make determinations by each of two or more methods. This gives a two-way or cross design which may or may not be nested each way. Obviously three- or more-way crosses could be (and undoubtedly have been) used.

Interlaboratory studies sometimes use two or three materials. Even in the case where each laboratory makes only one determination per material, the use of more than one material per laboratory provides information on laboratory "biases." The analysis of data of this type is usually made in accordance with conventional two-way analysis of variance procedures (**2**, p. 888f; **3**), but an ingenious graphical method has recently been developed (**4**). Both of these methods require that the within-laboratory test error be the same for all laboratories and materials. If this is not the case, the analysis of the data has often been carried out separately for each material, in accordance with the usual "between-within" type of analysis of variance (**3**, **5**).[4] However, in cases in which the standard deviation of the within-laboratory error is a known function of the magnitude of the measurement, an appropriate transformation of the data prior to analysis will ensure a homogeneous error term and permit a two-way analysis of variance. In particular, the simple logarithmic transformation is often used (**6**, pp. 116, 137); it is based on the assumption of a constant coefficient of variation (error proportional to magnitude) for within-laboratory test error. The study which we report in this paper, Bekk smoothness, is an example of a proportional type of error. In many cases a straight-line relationship with nonzero intercept, rather than a simple proportionality, is found (see Eq 1) and, hence, the transformation given in Eq 2 is required.

If an interlaboratory test has been run in accordance with a two-way classification with replications within cells, such as shown in Table I, it is usually interpreted on the basis of a model allowing for constant laboratory differences ("biases") and, in the case of a significant interaction term, for an additional random "variable bias" (**6**, p. 124). According to such a model, the response lines of all laboratories are necessarily parallel to each other, except for random scatter, and a plot of the results of one laboratory *versus* those of another is a straight line of 45 deg slope. This follows from the assumption that the "variable bias" is a random effect. It appears, therefore, merely as additional scatter about the 45-deg line.

There is, however, considerable evidence for the existence of nonconstant, nonrandom differences between labora-

[4] Tentative Recommended Practice for Interlaboratory Testing of Textile Materials (D 990 – 54 T), 1958 Book of ASTM Standards, Part 10.

tories. The Bekk smoothness data of Table II are shown graphically in Fig. 7. The nonparallelism of the lines is quite evident. The Bekk smoothness test is a physical test. However, the same type of results has been obtained with chemical tests. Figure 8 shows the relationship between the results obtained by two laboratories in the determination of pentosans in a series of pulp samples using a colorimetric method. Despite the fact that each laboratory prepared a calibration curve of the intensity of the color in terms of samples of known composition, the relation between the results of the two laboratories is definitely not the expected straight line of slope one and passing through the origin. Nor does a constant bias for each laboratory explain their relationship. It is seen that while a straight line is an adequate representation of this relation, this line has a slope distinctly different from unity, in addition to a nonzero intercept.

The conventional model for two-way classification data has a further disadvantage when applied to interlaboratory data. It is extremely sensitive to "outlying" data. Even a single outlier may result in a considerably enlarged interaction term. The practice of eliminating outliers on the basis of control-chart procedures has often led to the discarding of a substantial proportion of the participating laboratories. It is probably for these reasons that interlaboratory studies have been considered to be so "frustrating" (**7**).

The model presented in this paper allows for nonconstant, nonrandom differences between laboratories, by allowing their response lines to have slopes different from 45 deg, in addition to nonzero intercepts. It safeguards against the effect of outliers in two ways: by a preliminary analysis of the relation between within-cell variability and cell average, and by a separate calculation, for each individual laboratory, of the scatter of its points about its response line. It is believed that this model provides an adequate basis for the general description of the precision of measuring processes and a satisfactory procedure for analyzing and interpreting interlaboratory studies.

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APPENDIX

COMPUTATIONS

The computations are set forth in steps which are numbered identically as in the body of the paper.

Step 1. Scale Transformation

Compute, for each cell of Table I, its average and its standard deviation. Denote the average of the i,jth cell by y_{ij} and its standard deviation by s_{ij}. Then for each material (that is, column) compute the average $\bar{y}_j$ of the cell averages y_{ij} and the average $\bar{s}_j$ of the standard deviations s_{ij}. The results are shown in Table II for the Bekk smoothness data. Prepare a graph plotting the standard deviation $\bar{s}_j$ *versus* the average $\bar{y}_j$, as in Fig. 9, and fit a simple curve to the points thus obtained. For the data of Fig. 9, a straight line through the origin is a good fit. In general, a straight line, not necessarily passing through the origin, will be sufficient, as only an approximate, order-of-magnitude relationship is required. Determine the intercept A and the slope B of this straight line, in accordance with the equation:

$$\bar{s}_j = A + B\bar{y}_j + \text{(random fluctuation)} \quad (1)$$

For the Bekk smoothness data, this equation is given by $A = 0$ and $B = 0.128$.

If the slope B is appreciably different from zero, use the transformation

$$z = K \log (A + By) - C \ldots (2)$$

where K and C are arbitrary constants, the values of which are chosen on the basis of convenience. Theoretically, the transformation should be applied to each of the n observations in each cell. In most cases, however, it is sufficient to apply the transformation to the cell averages. Table III(a) shows schematically the transformed averages z_{ij} for each cell, and Table III(b) shows the transformed averages for the Bekk smoothness data. Since, for these data, we found $A = 0$, Eq 2 becomes, in this case,

$$z = K \log y - (C - K \log B)$$

It was convenient to make $K = 1000$ and $C - K \log B = 0$. Thus, the transformation, here, is simply $z = 1000 \log y$.

As a result of the transformation, the error ω has been transformed into a different error, denoted by ϵ, the variance of which is constant for all cells in Table III. Its value is given by the following expression:[5]

$$V(\epsilon) = \left(\frac{KB}{2.3}\right)^2 \ldots\ldots\ldots (3)$$

For the Bekk smoothness data we find

$$V(\epsilon) = \left(\frac{1000 \times 0.128}{2.3}\right)^2 = 3097$$

Since each cell contained 8 replicates, the standard error of a cell average is $\sqrt{3097/8} = 19.7$.

[5] The numerical factor 2.3 is due to the use of logarithms to the base 10 and equals $\log_e 10$.

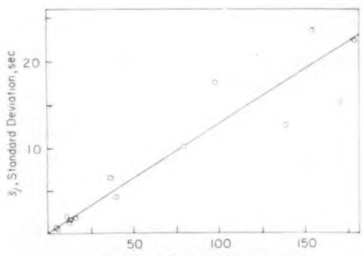

Fig. 9.—Bekk smoothness data, showing approximate linear relationship between standard deviation and magnitude of the smoothness value. The straight line is: $\bar{s}_j = 0.128\ \bar{y}_j$. Thus $A = 0$ and $B = 0.128$.

If the slope B is not appreciably different from zero, no transformation of scale is required and all subsequent steps are carried out on the original cell averages. In this case, $y = z$ and $\omega = \epsilon$.

Step 2. Determination of μ_i, β_i, and $V_i(\eta)$

First compute the row and column averages in Table III(a) as follows:

$$\mu_i = \frac{1}{b} \sum_j z_{ij} \ldots\ldots\ldots\ldots (4)$$

$$x_j = \frac{1}{a} \sum_i z_{ij} \text{ and } \bar{x} = \frac{1}{b} \sum_j x_j \ldots (5)$$

Then compute the quantities below in the indicated order:

$$X = \sum_j x_j^2 - b\bar{x}^2 \quad \ldots\ldots(6)$$

$$Z_i = \sum_j z_{ij}^2 - b\mu_i^2 \quad \ldots\ldots(7)$$

$$P_i = \sum_j x_j z_{ij} - b\mu_i\bar{x} \quad \ldots\ldots(8)$$

$$\beta_i = \frac{P_i}{X} \quad \ldots\ldots(9)$$

$$V_i(\eta) = \frac{a}{a-1}\cdot\frac{1}{b-2}\left[Z_i - \frac{P_i^2}{X}\right] \quad \ldots(10)$$

The last formula constitutes a slight departure from the ordinary calculations in linear regression: the correction factor $a/(a-1)$ is due to the fact that the errors of z_{ij} and x_j are slightly correlated.

The results of these computations for the Bekk smoothness data are shown in Table IV.

Determination of $V(\mu)$ and $V(\lambda)$

To obtain $V(\eta)$, average all values of $V_i(\eta)$ (see Table IV). $V(\lambda)$ is given by the following equation:

$$V(\lambda) = V(\eta) - (1/n)\, V(\epsilon) \quad \ldots(11)$$

where $V(\epsilon)$ is given by Eq 3. Should the estimate of $V(\eta)$ be less than that of $(1/n)\, V(\epsilon)$, then $V(\lambda)$ must be considered to equal zero. For the Bekk smoothness data, we obtain $V(\lambda) = 596 - (3097/8) = 209$.

Step 3. Determination of Variances

Table $V(a)$ is constructed in the usual manner, using the transformed cell averages. Note that $S_M = aX$ where X is given by Eq **6**, and that

$$S_{LM} = \left(\sum_i Z_i\right) - S_M = \left(\sum_i Z_i\right) - aX \quad \ldots(12)$$

The variances $V(\mu)$ and $V(\beta)$ may now be obtained from the previously obtained value of $V(\eta)$ and from Table $V(a)$.

$$V(\mu) = \frac{M_L - V(\eta)}{b} \quad \ldots\ldots(13)$$

$$V(\beta) = \frac{A\,[M_{LM} - V(\eta)]}{M_M - V(\eta)} \quad \ldots(14)$$

If either of these equations yields a negative value, the corresponding variance is taken to be zero.

The quantity $V(\delta)$ is obtained from the following equation:

$$V(\delta) = V(\beta) - \alpha^2 V(\mu) \quad \ldots\ldots(15)$$

where $V(\beta)$ is given by Eq 14 and α by the equation:

$$\alpha = \frac{ab\left[\sum_i \mu_i P_i - \bar{x}\sum_i P_i\right]}{S_L S_M} \quad \ldots(16)$$

For the Bekk smoothness data, these computations yield:

$$V(\mu) = 3296 \qquad V(\beta) = 0.002881$$
$$\alpha = 0.0004661$$
$$V(\delta) = 0.002881 - 0.000716 = 0.002165$$

Step 4. Breakdown of Total Variance

The total variance of z, for any value of z, is given by the equation:

$$V(z) = V(\epsilon) + V(\lambda) + [1 + \alpha(z - \bar{x})]^2\, V(\mu) + (z - \bar{x})^2 V(\delta) \quad \ldots(17)$$

From this equation we derive, by dividing by $V(z)$, the breakdown of the total variance into its fractional parts:

$$1 = \frac{V(\epsilon)}{V(z)} + \frac{V(\lambda)}{V(z)} + \frac{[1 + \alpha(z - \bar{x})]^2 V(\mu)}{V(z)} + \frac{(z - \bar{x})^2\, V(\delta)}{V(z)} \quad (18)$$

This information is tabulated in Table VI for the Bekk data, for values of z corresponding to some selected values of y covering the range of interest.

Step 5. Conversion to Original Scale

The total variance of z is converted back to the y-scale by means of the equation:

$$V(y) = \left[\frac{2.30}{K}\left(\frac{A}{B} + y\right)\right]^2 V(z) \quad (19)$$

It is generally desirable to add two more columns to the table showing the breakdown of $V(z)$: a column of the selected values for which the breakdown was made and a column of σ_y, obtained by taking the square root of Eq 19 (see Table VI).

Technical Note

The Effect of Temperature Interruption on Anelastic Creep

EXPERIMENTS (**1**)[1] on an alloy steel in the temperature range from 800 to 1100 F have indicated that anelastic strain[2] might be used to counteract the plastic creep[2] rather than adding to it, if a prestraining treatment were performed at a stress higher than the service stress. In order to take advantage of this possibility commercially, it would generally be necessary to perform a machining operation between prestraining and service to obtain accurate dimensions of the finished part. Machining would be done at room temperature, and so the anelastic strain from the prestraining would have to be "frozen-in" at room temperature if it is to be available afterward to counteract the plastic strain in service. The general concepts of anelastic behavior, based on experiments at very small stresses (**2**), indicate that anelastic strain would be frozen in by lowering the temperature sufficiently, but no direct evidence is available. The following tests were conducted to see directly whether freezing in of anelastic strain is feasible under stress conditions of commercial significance.

The material used was a 0.99 Cr, 0.58 Mo, 0.31 V steel with 0.41 per cent carbon, oil quenched from 1650 F as a 3-in. round, and tempered 12 hr at 1240 F. The equipment, described elsewhere (**3**) used a 10-in. long, 0.505-in. diam specimen. The relative motion

TABLE I.—SUMMARY OF RESULTS.

	Interrupted		Not Interrupted	
	Test No. 1	Test No. 2	Test No. 3	Test No. 4
E (millions of psi):[a]				
Loading	22.9	25.1	22.5	23.4
Unloading	20.4	22.2	22.9	23.7
Creep, mils per in.	2.28	1.77	2.53	1.64
Creep recovery, mils per in.	0.75	0.66	0.84	0.64
Average creep, mils per in.	2.02		2.08	
Average creep recovery, mils per in.	0.70		0.74	

[a] To avoid errors near zero load, the modulus of elasticity was determined between 4000 and 22,000 psi.

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[1] The boldface numbers in parentheses refer to the list of references appended to this paper.

[2] Creep strain may be divided into two parts: (*a*) anelastic strain, or that which is recovered upon removing the load; and (*b*) plastic strain, or that which is not recovered upon removing the load (**1**).

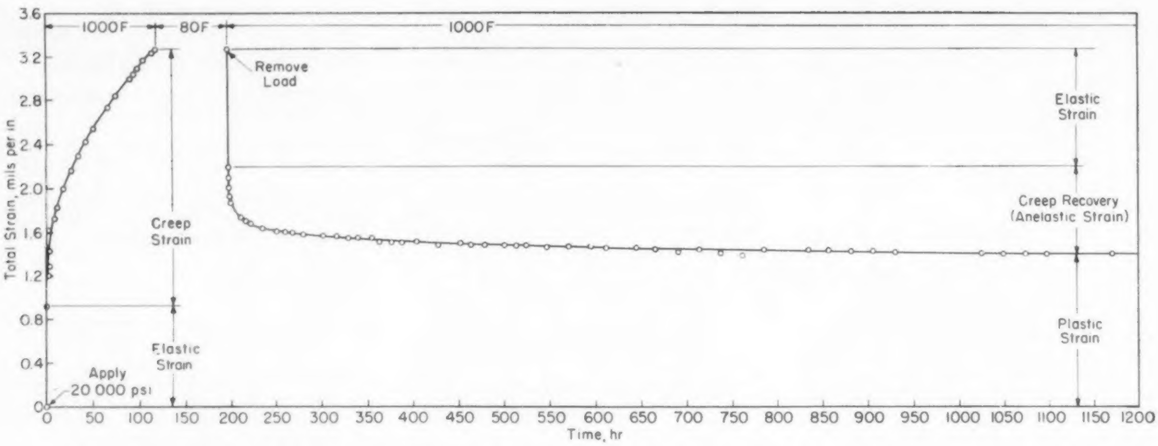

Fig. 1.—Creep test of Cr-Mo-V steel at 1000 F, with load removed after an interruption at room temperature, test No. 1.

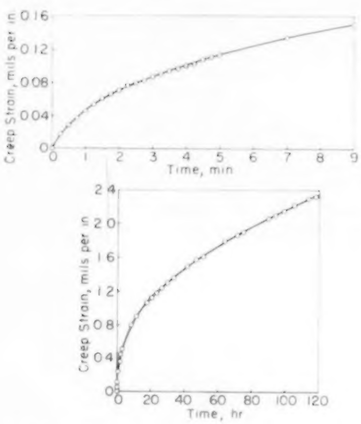

Fig. 2.—Magnification of the creep in Fig. 1.

of split clamps at the ends of the gage length was measured by a 0.0001-in. dial gage. To insure that the creep gages were functioning properly, the modulus of elasticity of each specimen was determined before the test.

Two pairs of duplicate tests were made at 1000 F, one pair having an interruption at room temperature after prestraining and the other not. In all four tests the prestraining consisted of 120 hr at 22,000 psi, and the resultant anelastic shortening was observed during a very long period following unloading. In one pair of tests the prestraining load was removed without any change in temperature, and in the other pair the temperature was lowered to room temperature after the prestraining and then returned to 1000 F for observation of the creep recovery. To insure that no anelastic strain would be lost at temperatures slightly below the test temperature, the specimens were cooled and heated with the load on. Removal of the load while the specimen was cold revealed that no length changes were occurring. The load was removed immediately after reheating to 1000 F.

Figures 1 to 3 show typical creep and creep recovery curves. These curves are representative of tests both with and without a temperature interruption. Figure 1 shows the entire test, while Figs. 2 and 3 show in more detail the creep and creep recovery. A summary of all test results is given in Table I, which shows that the anelastic strain was about one-third of the creep strain, and that there was good reproducibility in duplicate tests. The results show that the same anelastic shortening occurs after unloading from the same preloading treatment, regardless of whether the metal was at room temperature after the prestraining or not. In other words, freezing-in of anelastic strains is feasible under stress conditions of commercial significance, and therefore can be used to counteract plastic strain in service.

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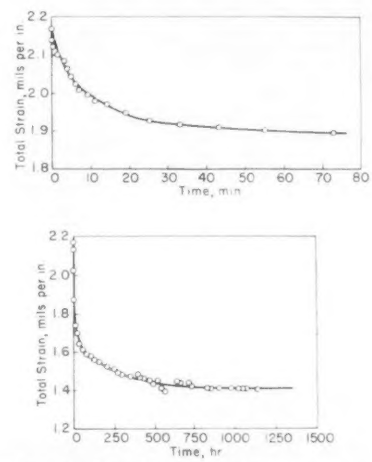

Fig. 3.—Magnification of the creep recovery in Fig. 1.

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The Influence of the Direction of Loading on the Strength of Concrete Test Cubes

By A. M. NEVILLE

THERE has been a considerable amount of discussion from time to time on the relative merits of the various shapes of the compression test specimens. In particular, it has been suggested that the standard cube test, used in Great Britain, presents a "more realistic and reliable indication of the compression strength of concrete in horizontal flexural members than is obtained by the use of standard cylindrical specimens" (**1**).[1] On the other hand, it has been claimed that use of cylindrical test specimens is preferable because the load is applied in the same direction in which the specimen was cast, and this is what generally happens in an actual compression member of a reinforced concrete structure.

It is only fair to add that whatever the type of test specimen used, its compressive strength is not the same as the compression resistance of a member of the concrete structure. However, subject to a satisfactory workmanship in the placing of the concrete both in the test specimen and in the actual structure, the test specimen strengths may be considered to be indicative of the quality and uniformity of the concrete in the actual structure.

The practical problem (encountered particularly in work in foreign countries where the testing specifications are different from those in the contractor's home country) of "conversion" of strength of specimens of different types presents some difficulties. The factors involved are the shape of the test specimen, its size (**2**) and proportions, and also the direction of the application of the load relative to the direction of casting. To know whether this last factor is real and significant would help in such attempts at conversion of strength between different types of specimens.

Existing Information

Gilkey and Leavitt (**3**) reported the strength of mortar cubes, capped and tested in the direction of casting, to be between 0.87 and 0.91 of the strength of similar cubes tested at right angles to the direction of casting, that is, in the standard manner. This difference was ascribed to the eccentricity of resistance of the standard test cube, the variation in the quality of the material in successive horizontal layers, as cast, resulting in the axis of resistance being somewhat nearer the base of the cube, as cast—that is, not coincident with the axis of the applied load. On the other hand, in cubes tested in the direction of casting and in cylindrical test specimens the load applied along the geometric axis of the specimen is collinear with the axis of resistance. These phenomena are connected with water-gain ("bleeding"), and would not be expected in a homogeneous specimen made of unsegregated material. If, however, the segregation of concrete results in some stratification, then, according to Gilkey and Leavitt (**3**), in the "on top" test the strength measured would be that of the weakest part of the specimen, presumably its top part. On the other hand, in the standard cube test the strength observed would be the mean of all the "links" of different strengths. In actual fact the problem would be more complicated because of the dependence of the modulus of elasticity of concrete in each link, and therefore its deformability, on the strength of concrete.

More recently, Mercer (**1**) became interested in the problem of the influence on the strength of the direction of testing relative to the direction of casting, and suggested that concrete is basically aeolotropic. He cast eight batches of six cubes, and tested half of each batch in the direction of casting, the other half being tested in the standard manner. From these few tests he concluded that testing in the direction of casting results in a higher strength (of between 10 and 20 per cent) as compared with the standard cube test. Mercer's cubes tested in the direction of casting were capped but no information on the type of capping was given, and therefore no knowledge of its possible influence is available.

Johnson (**4**) found that cylinders cast in the standard manner (that is, in the direction in which the load will be applied) have a strength about 5 per cent higher than the strength of cylinders cast with the axis in a horizontal position. It seems probable that the difficulty of casting and compacting the concrete in the horizontal cylinders seriously affected their strength results.

It can be seen that some of the results quoted above are mutually contradictory, and little information on the influence of the direction of loading on the strength of a specimen of a given shape seems to be available. In particular, nothing is known about the variability of the specimens tested in the two directions, and it is possible that even if the mean strength is unaffected, the standard deviation depends on the direction of application of the load. The present paper attempts to assess these influences.

Experimental

In this investigation 16 batches of 12 cubes each were tested, the load on half the cubes in each batch being applied in the direction of casting, the other half being tested in the standard manner. In all cases the load was applied at the rate of 2000 psi per min. Thirteen concrete mixes and three mortars were tested.

One batch of type III cement was used for all the tests. The aggregate was dried to a saturated surface-dry condition and sieved into fractions. This made possible the reconstitution of four gradings, as shown in Fig. 1, with the object of observing the possible effects of segregation on the strength of specimens tested in the direction of

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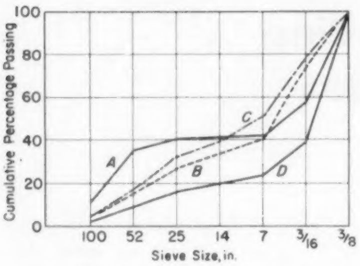

Fig. 1.—Grading curves.

casting. The maximum size of the aggregate was $\frac{3}{8}$ in., and this made possible the use of 3-in. cubes. However, to check whether the effects of segregation are not more prominent in larger specimens, two batches of 6-in. cubes were made.

All ingredients of the mixes were weigh-batched. The concrete was mixed by hand, and the cubes were compacted by hand in three layers in the standard manner used in Great Britain (**5**). The cubes were then stored in laboratory air at a temperature of 18 ± 1 C until stripped 17 hr after casting when they were immersed in water at the same temperature.

Since the cubes could not be finished with a surface sufficiently smooth for testing, it was necessary to cap those cubes which were tested in the direction of casting. It was, of course, essential to ensure that the capping did not influence the test results.

The capping was of rapid hardening dental plaster (E.P.1) applied in a thickness of $\frac{1}{16}$ in. about 45 min before testing, a smooth surface being obtained through contact with a glass plate. As a check on the absence of the influence of capping on strength a batch of twelve cubes was cast and half the cubes were capped on two opposite sides. All the cubes were then tested with the load acting at right angles to the direction of casting. The mean strengths of the normal and capped cubes were 4716 and 4598 psi respectively, the corresponding standard deviations being 117 and 140 psi. A t-test[2] shows no significant difference between the means of the two samples, and the F-test[2] indicates no significant difference between the sample variances.

These results cannot, however, be considered conclusive, and therefore in order to avoid the possibility of the capping influencing the test results, all specimens in the main series of tests (Table I) were capped on one face: a side of the cube for those tested in the standard manner, and on the top surface for the cubes tested in the direction of casting. It is realized that Poisson's ratio of the capping material is not the same as that of concrete and the capping may therefore modify the friction effects of the platen of the testing machine (**6**).

Discussion of Results

From Table I it can be seen that for cohesive mixes (grading curves A, B, and C) there appears to be no significant difference either between the mean strengths or between the variances of the samples tested in the two

[2] These standard statistical tests are described in any textbook of statistics.

TABLE I.—TEST DATA AND RESULTS.

Test	Water-Cement Ratio by Weight	Aggregate-Cement Ratio by Weight	Grading Curve (Fig. 1)	Cube Size, in.	Age at Test, Days	Direction of Application of Load	Mean Strength of Sample, psi	Sample Standard Deviation, psi	Coefficient of Variation, per cent	t^a	$F^{a,b}$
No. 1....	0.413	3	A	3	7	Standard As cast	5001 4331	596 385	11.90 8.89	2.16	1.80
No. 2....	0.429	3	A	3	4	Standard As cast	4393 4127	385 219	8.77 5.30	1.36	2.75
No. 3....	0.429	3	A	3	7	Standard As cast	5276 4812	362 491	6.86 10.22	1.67	2.22
No. 4....	0.667	6	B	3	7	Standard As cast	3194 3182	165 195	5.17 6.12	0.10	1.40
No. 5....	0.800	7	B	3	7	Standard As cast	2414 2339	117 155	4.84 6.63	0.86	1.88
No. 6....	0.800	7	B	3	35	Standard As cast	2624 2819	159 131	6.06 4.64	2.10	1.69
No. 7....	0.670	6	B	6	5	Standard As cast	3017 2807	84 177	2.78 6.31	2.34	5.11
No. 8....	0.430	3	C	3	7	Standard As cast	6068 5604	396 446	6.52 7.96	1.73	1.49
No. 9....	0.800	7	C	3	8	Standard As cast	2496 2371	82 167	3.29 7.04	1.48	4.58
No. 10...	0.416	3	D	3	7	Standard As cast	4953 4970	160 235	3.23 4.73	0.13	2.14
No. 11...	0.690	7	D	3	7	Standard As cast	2170 2350	120 122	5.53 5.19	2.35	1.13
No. 12...	0.636	7	D	3	35	Standard As cast	3675 3949	155 80	4.22 2.03	3.43	4.32
No. 13...	0.690	7	D	6	7	Standard As cast	2309 2232	117 81	5.07 3.63	1.21	1.95
No. 14...	0.400	3	Standard Sand	3	28	Standard As cast	6173 5832	230 322	3.73 5.52	1.88	2.05
No. 15...	0.400	3	Standard Sand	3	120	Standard As cast	7297 6760	171 463	2.34 6.85	2.31	8.54
No. 16...	0.400	3	Standard Sand	3	180	Standard As cast	7284 6803	542 373	7.44 5.48	1.64	1.84

[a] For 5 per cent significance level: $t_{10} = 2.23$ and $F_{5,5} = 5.05$.
[b] F-test based on the coefficients of variation (**7**).

directions. The only exception is mix No. 7, which shows a difference at the 5 per cent significance level both in strengths and variances.[3] For this test the mean strength of cubes tested in the standard manner was 7 per cent higher than the strength of the cubes tested in the direction of casting.

In mixes Nos. 10 to 13 the aggregate with a coarse grading (grading curve D) was used in order to encourage some segregation. Two tests show no difference in strengths, while the other two indicate a difference at the 5 per cent significance level. The specimens tested in the direction of casting show a mean strength approximately 8 per cent higher than the strength of similar specimens tested in the standard manner. It therefore seems possible that segregation affects the strength of a cube—depending on the direction of application of the load. The exact mechanism is by no means clear but it is possible that in the "on top" test the load always acts over the whole area of the cube which deforms uniformly for all vertical elements. On the other hand, in the standard test the weaker part of the cube extends continuously between the platens of the testing machine and, having a lower modulus of elasticity, may deform more and thus throw the whole load onto the stronger part of the cube. Thus the effective area resisting the load would be smaller than the cross-sectional area of the cube. This argument implies that once the test has started the spherically-seated platen of the testing machine cannot alter its inclination and moves only in a direction parallel to itself; such behavior has been observed in practice when greased surfaces of the spherical seat offer high friction. The use of a highly polar lubricant can lower the coefficient of friction to a value as low as 0.04, and permit movement of the platen during the test (**8**).

No significant difference in variances was observed, and this would mean that the variability of strength results was not affected by the direction of application of the load.

[3] To allow for the increase in the standard deviation with increase in mean strength, the F-test was applied to the squares of coefficients of variation (**7**).

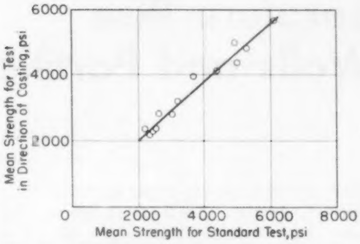

Fig. 2.—Relation between mean strengths of concrete cubes loaded in the direction of casting and in the standard manner.

A mortar made with the standard Leighton Buzzard sand (siliceous material, all of one size, between No. 18 and No. 25 sieves) has shown no difference in either the mean strength or the sample variance in two cases, and a difference at the 5 per cent significance level in one case, where the standard test showed a higher strength than when the load was applied in the direction of casting. It may be observed that mortar made with one-size aggregate tends to be considerably less homogeneous than mortar made with graded aggregate, and has therefore a much higher variance.

Figure 2 shows a plot of mean strength of samples tested in the standard manner against the strength of similar samples tested with the load applied in the direction of casting. The regression line is also shown, and the significance level of this apparently linear relationship is considerably better than 0.1 per cent. It is possible that at higher stresses—above 4000 psi approximately—the specimens tested in the direction of casting show a *slightly* lower strength than similar specimens tested in a standard manner; this difference is of the order of 4 to 7 per cent. It has not been established, however, that, within the range of variables investigated, there is a *significant* difference between the strengths of specimens tested in the two directions. The variances do not show a significant difference either. When segregation takes place, the lack of homogeneity of the concrete in the specimen may be reflected in a difference between the strengths of the specimens tested in the two directions.

Thus, provided the specimens are made of cohesive concrete and are well compacted, and are tested so that the applied load is approximately uniformly distributed over the loaded surface throughout the duration of the test, the direction in which the load is applied relative to the direction of casting is not expected to influence their strength.

Acknowledgment:

The author is grateful to Miss H. Kurdi who ably performed the experimental part of the investigation.

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Prediction of Temperature Rise in Fire Testing of Walls and Partitions

By R. H. NEISEL

Empirical formulas have been developed whereby the fire rating of wall panels may be predicted from the thickness, density, and thermal conductivity of the wall material or materials. The prediction relates only to the temperature-rise rating and not to structural integrity, which is primarily a function of the method of assembly.

The method appears to be applicable to sandwich-type walls which incorporate low-density insulating materials as well as to walls of more conventional high-density materials. Previous publications (1, 2, 4)[1] have reported relationships for dense materials and have postulated methods of data extrapolation for prediction of fire ratings. The present discussion presents a method of prediction which is applicable to a wide range of materials.

In the design of fire-rated walls or partitions, it is necessary to specify the material or materials, the thickness, and the method of securement. In most building codes, specified thicknesses of standard materials are accepted for stated fire-resistance periods. Walls of other material must be tested, usually in conformance with ASTM Method of Fire Tests of Building Constructions and Materials (E 119 – 55)[2] in order to establish the fire resistance period.

One of the conditions for acceptance stated by E 119 – 55 is that "Transmission of heat through the wall or partition during the fire endurance test shall not have been such as to raise the temperature on its unexposed surface more than 250 F above its initial temperature."

This condition is based on the fact that many combustible materials will ignite at temperatures of 300 F to 400 F. Thus, where combustible materials are in contact with the unexposed face of a fire wall, ignition of those materials and consequent spread of the fire will occur when the temperature has risen 250 F (a final temperature of 325 F where the initial temperature is 75 F). The time required for that temperature rise has therefore been established as one of the criteria for rating of walls under conditions of fire exposure.

Based on tests performed at the Johns-Manville Research Center, an empirical method of prediction of temperature-rise ratings has been developed which is applicable to walls constructed of low-density materials or to combination walls. For general application, the prediction is made from consideration of the density, thermal resistance, and weight per square foot of the wall. For high-density materials, the formula evolves into a form similar to that proposed by others.

Use of this method should considerably decrease the amount of exploratory testing necessary to establish required material thickness for specified ratings. Determination of structural integrity must, of course, be established through full-scale tests.

Test Procedure

The majority of the tests for this study were performed in a small-scale fire test furnace which complies in many respects with the suggested specifications in H. D. Foster's article (**7**). This furnace has a combustion chamber 20 in. wide, 25 in. high, and 15 in. deep. Heat is supplied by eight small gas burners set into the rear wall. Furnace temperatures are measured by two 8-gage chromel-alumel thermocouples enclosed in stainless steel protection tubes. The tubes project 13 in. into the furnace and the ends are located 2 in. from the face of the test sample. The test opening measures 20 by 20 in. while the enclosure frame for the sample measures 25 by 25 in.

The maximum size of specimen which the furnace is capable of testing is 2 by 2 ft. All specimens tested in the course of this investigation were that size.

Prior to testing, the specimens were conditioned for at least 4 days at 75 F and 50 per cent relative humidity. Dimensions and weights of the components and of the assembled specimen were determined after conditioning.

The average furnace temperature was controlled to the standard time-temperature curve given in ASTM Method E 119.[2] Unexposed surface temperatures were read at the specimen midpoint with 22-gage chromel-alumel thermocouples covered by standard felted asbestos fire-test pads.

Results of previous tests conducted in several other furnaces were also considered. These furnaces took specimens varying greatly in size: 7 by 7 in., 12 by 12 in., 4 by 5 ft, and 4 by 8 ft. The 7 by 7 and 12 by 12-in. furnaces tested the specimens in the horizontal position while the other furnaces tested specimens in the vertical position.

Treatment of Data

The data were treated in several ways in order to ascertain whether a consistent relationship of time for a 250 F temperature rise to various parameters would appear. No such relationship was apparent when panel thickness or weight was used as the variable. It appeared that thermal diffusivity might be a logical property to investigate, but it was soon realized that diffusivity does not take into account the effect of variation in thickness. Thermal diffusance, to coin a term, was then defined as thermal conductivity divided by the heat capacity per unit area of a panel. Neither did this property show any consistent relationship. Moreover, accurate values of specific heat at elevated temperatures were not readily available for many materials.

It was then decided that the lack in the characteristics investigated was that none took into account both the thermal resistance and the heat capacity of the wall. Because of the lack of information on specific heat at high

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NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] The boldface numbers in parentheses refer to the list of references appended to this paper.

[2] 1958 Book of ASTM Standards, Part 5, p. 969.

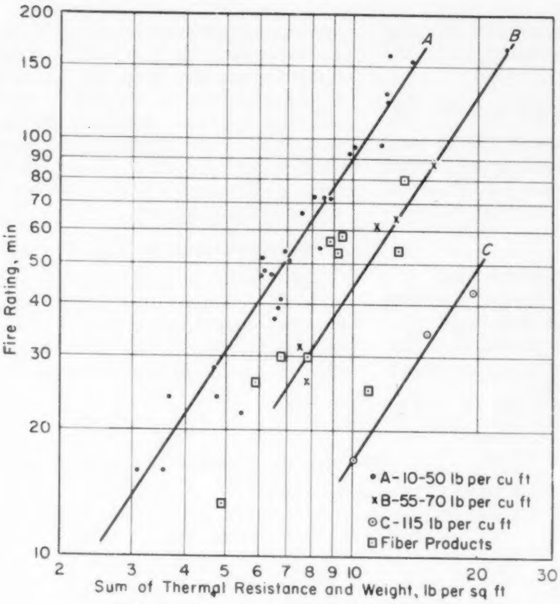

Fig. 1.—Fire rating prediction curves.

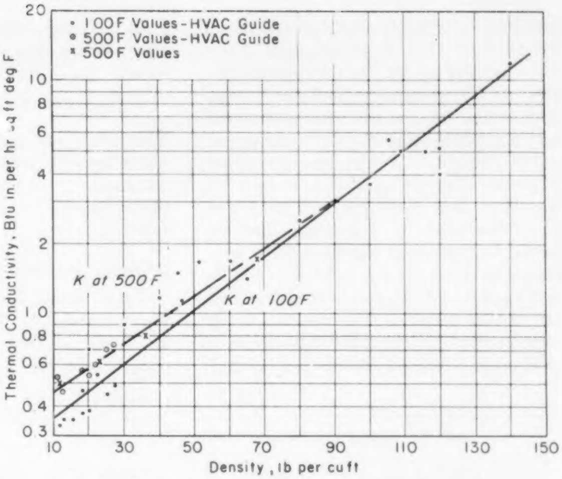

Fig. 2.—Relation of thermal conductivity to density.

temperature, it was decided to assume that specific heat of all materials was equal and to use panel weight per square foot as a measure of heat capacity.

The time in minutes required for a 250 F temperature rise was plotted against the sum of the panel weight in pounds per square foot and the thermal resistance in deg Fahr hr sq ft per Btu at 500 F mean temperature. Study of data for both short- and long-term tests has indicated 500 F as a reasonable average mid-thickness temperature. Straight-line relationships were found when the results were plotted on log-log paper, indicating an exponential relationship (Fig. 1). The data were found to fall, in general, on three straight lines. The majority of the data included materials in the density range from 10 to 50 lb per cu ft and these fell on a common line. Materials ranging from 55 to 70 lb per cu ft fell on a second common line, while flat asbestos-cement sheets seemed to fall on a third line.

The equation for the line formed by the materials of 10 to 50 lb per cu ft (test Nos. 1 to 22, 36, 38, 39, and 41 to 43) was calculated by the method of least squares and found to be:

$$\log F = 0.41030 + 1.54244 \log N \quad \ldots (1)$$

where:

F = fire rating, min., and
N = thermal resistance, deg Fahr hr sq ft per Btu, plus weight lb per sq ft

The correlation coefficient was calculated and found to be 0.96, indicating extremely good fit.

As the number of points available in the density ranges 55 to 70 and 110 to 120 lb per cu ft was small, no attempt was made to calculate the regression equation. Instead, lines *B* and *C* were drawn to have a slope similar to line *A* (10 to 50 lb per cu ft) and in positions deemed most suitable as indicated by the individual results.

The above equation can also be expressed as:

$$F = 2.57N^{1.54} \quad \ldots (2)$$

but the log form seems more useable.

The equation can be further broken down to the form:

$$\log F = 0.41030 + 1.54244 \log \left(\frac{d}{k} + \frac{\rho d}{12}\right) \quad \ldots (3)$$

where:

d = thickness, inches
k = thermal conductivity at 500 F mean, Btu in. per hr sq ft deg F
ρ = density, lb per cu ft

For two or more materials placed in series, the bracketed quantity above would become:

$$\frac{d_1}{k_1} + \frac{d_2}{k_2} + \ldots\ldots \frac{\rho_1 d_1}{12} + \frac{\rho_2 d_2}{12} \ldots\ldots$$

with k taken at appropriate mean temperatures.

Thermal Conductivity

The values of thermal conductivity shown in Table I were taken from tests made at the Johns-Manville Research Center. In most instances values were obtained from conductivity *versus* mean temperature curves developed from data obtained with Alundum guarded hot plates constructed and operated in conformance with ASTM Test Method (C-177 – 45).[3] For those few materials which could not be brought to thermal equilibrium at 500 F mean temperature due to physical changes or apparatus capacity, the results were extrapolated from conductivity values obtained at lower temperatures.

It is not believed that conductivity test determinations on low-density fibrous materials in the guarded hot plate apparatus adequately simulate conditions existing under fire conditions. The guarded hot plate apparatus used at mean temperatures near 500 F accepts 1-in.-thick samples placed in the horizontal position. As mounted in walls exposed to fire, these materials will be mounted vertically, in thicknesses up to 4 in. and will have a greater temperature differential from face to face. Under such conditions it appears that heat flow through the material will be higher than predicted because of factors such as convection currents and radiation.

It is realized that thermal conductivity values for all materials may not be available. In the absence of that information an estimate of thermal conductivity from density would be useful. Such a relationship for solid, nonmetallic materials of densities from 10 to 150 lb per cu ft was established as described below.

Effect of Density on Thermal Conductivity

Values of density and thermal conductivity at 100 F and 500 F mean tem-

[3] ASTM Method of Test for Thermal Conductivity by Guarded Hot Plate (C 177 – 45), 1958 Book of ASTM Standards, Part 5, p. 828.

perature were taken from the Heating, Ventilating, Air Conditioning Guide 1958 published by the American Society of Heating and Air Conditioning Engineers. The values were plotted on semilog paper as in Fig. 2. Additional values presented in this paper were also plotted. The apparent line of best fit was then drawn for the two temperature conditions. It was found that, as would be expected, two lines were necessary in the density range below 100 lb per cu ft but that the lines converged above that density. This appears to be in agreement with heat flow theory.

The relationship between density and thermal conductivity at 500 F mean temperature may be described by the equation:

$$\log k = -0.44062 + 0.01039\, \rho \quad (4)$$

This relationship should only be used when specific information on thermal conductivity is lacking, but it should prove valuable in preliminary calculations.

Effect of Density on Fire Rating

Fire ratings for various materials were calculated for 2-in. and 4-in. thicknesses. When plotted on linear paper, as in Fig. 3, it was found that a maximum point appeared in the density range 30 to 40 lb per cu ft. From this it appears that 30 to 40 lb per cu ft is the optimum density for fire-wall materials and that excellence for use may be judged by whether the thermal conductivity of particular materials in that density range is significantly lower than that expressed above.

Combined Formula for Fire Rating

The formula for fire rating expressed in terms of density and thermal conductivity may be combined with the density-thermal conductivity relationship to give a generalized form ex-

TABLE I.—MATERIALS AND RATINGS OF VARIOUS PANELS.

Test	Furnace	Covers	Core			Panel			Thermal Conductivity, Btu in. per hr sq ft deg Fahr		Thermal Resistance		N[c]	Tested Rating, min	Estimated Rating, min[e]
			Material	Density, lb per cu ft	Thickness, in.	Thickness, in.	Weight, lb per sq ft	Bulk Density, lb per cu ft	Covers[a]	Core[b]	Covers	Core			
No. 1..	1	None	Calcium silicate, block A	12.0	2.34	2.34	2.3	12.0	...	0.50	...	4.68	6.98	51	52
No. 2..	1	None	Calcium silicate, block A	15.0	3.01	3.01	3.8	15.0	...	0.50	...	6.02	9.82	94	87
No. 3..	1	None	Calcium silicate, block A	12.1	4.62	4.62	4.9	12.1	...	0.50	...	9.25	13.87	154	150
No. 4..	1	None	Magnesia block, 85 per cent	12.8	1.95	1.95	2.1	12.8	...	0.50	...	3.90	6.00	52	41
No. 5..	1	None	Magnesia block, 85 per cent	12.8	3.90	3.90	4.2	12.8	...	0.50	...	7.80	12.00	162	119
No. 16..	1	A	Calcium silicate, block A	14.0	2.00	2.25	4.8	25.6	6.0–4.5	0.50	0.05	4.00	8.85	72	74
No. 20..	1	A	Calcium silicate, block B	...	1.35	1.60	4.25	31.9	6.0–4.5	0.56	0.05	2.41	6.71	41	48
No. 43..	1	A	Calcium silicate, block B	...	1.31	1.56	4.00	30.8	6.0–4.5	0.56	0.05	2.34	6.39	47	45
No. 6..	4	A	Expanded perlite sheet	12.3	1.05	1.30	3.6	33.2	6.0–4.5	0.50	0.05	1.11	4.76	24	29
No. 19..	1	A	Cellular glass block	10.0	1.30	1.55	3.88	30.0	6.0–4.5	0.86	0.05	1.51	5.39	22	34
No. 29..	5	B	Cellular glass block	10.0	4.00	5.64	18.32	39.0	8.0	0.86	0.40	4.46	23.18	167	160B
No. 23..	1	None	Felted mineral fibers	6.0	4.45	4.45	1.9	6.0	...	0.50	...	8.90	10.80	25	...
No. 24..	1	A	Felted mineral fibers	7.2	2.03	2.28	3.73	19.7	6.0–4.5	0.50	0.05	4.06	7.84	30	30B
No. 25..	1	C	Felted mineral fibers	7.2	1.08	2.08	10.60	61.7	6.0–4.5	0.50	0.19	2.00	12.79	54	64B
No. 45..	2	D	Felted mineral fibers	4.4	3.00	3.88	5.84	18.1	2.1–1.5	0.60	0.52	4.99	11.35	62	53B
No. 52..	1	A	Felted mineral fibers	17.2	1.85	2.20	5.20	28.4	6.0–4.5	0.50	0.05	3.70	8.95	56	75
No. 53..	1	A	Felted mineral fibers	16.0	1.00	1.25	3.87	37.2	6.0–4.5	0.50	0.05	2.00	5.92	26	40
No. 54..	1	A	Felted glass fibers	1.0	2.00	2.24	2.39	12.8	6.0–4.5	0.80	0.05	2.59	4.94	13	14B
No. 55..	1	A	Felted glass fibers	6.2	2.00	2.25	3.37	18.0	6.0–4.5	0.60	0.05	3.33	6.75	30	24B
No. 26..	1	A	Low temp. min. fiber block	15.2	1.95	2.20	5.18	28.2	6.0–4.5	0.50	0.05	3.90	9.13	54	78
No. 28..	1	None	Low temp. min. fiber block	16.0	4.00	4.00	5.33	16.0	...	0.50	...	8.00	13.33	81	140
No. 39..	1	A	High temp. min. fiber block	19.8	1.94	2.15	5.43	30.3	6.0–4.5	0.50	0.05	3.88	9.36	59	81
No. 17..	1	A	Wood fiberboard	20.1	1.73	1.98	5.30	32.1	6.0–4.5	0.60	0.05	2.88	8.23	55	66
No. 18..	1	A	Wood fiberboard	19.8	1.29	1.54	4.40	34.3	6.0–4.5	0.60	0.05	2.15	6.60	39	47
No. 50..	1	A	Cane fiberboard	...	1.34	1.59	4.60	34.7	6.0–4.5	0.60	0.05	2.23	6.88	54	51
No. 51..	1	A	Cane fiberboard	...	1.33	1.58	4.30	32.7	6.0–4.5	0.60	0.05	2.22	6.52	37	46
No. 11..	1	A	Cement bonded wood fiber	34.0	1.39	1.64	6.9	50.5	6.0–4.5	0.80	0.05	1.74	8.69	74	72
No. 12..	1	A	Cement bonded wood fiber	21.8	1.36	1.61	5.4	40.3	6.0–4.5	0.62	0.05	2.19	7.64	70	60
No. 15..	1	A	Diatomaceous earth block	23.6	2.05	2.30	6.7	28.4	6.0–4.5	0.77	0.05	2.66	9.41	76	80
No. 41..	1	None	Felted asbestos	27.6	1.75	1.75	4.03	27.6	...	0.69	...	2.56	6.59	46	47
No. 7..	3	None	Calcium silicate sheet	24	0.85	0.85	1.70	24	...	0.62	...	1.37	3.07	16	15
No. 8..	3	None	Calcium silicate sheet	24	0.76	0.76	1.52	24	...	0.62	...	1.23	2.75	12	12
No. 9..	3	None	Calcium silicate sheet	27	1.21	1.21	2.72	27	...	0.62	...	1.95	4.67	28	27
No. 10..	3	None	Calcium silicate sheet	25	2.01	2.01	4.19	25	...	0.62	...	3.24	7.43	67	58
No. 14..	1	A	Calcium silicate sheet	23.9	1.76	2.01	6.60	39.4	6.0–4.5	0.62	0.05	3.22	9.90	96	88
No. 47..	2	None	Calcium silicate sheet	22.0	1.76	1.76	3.23	22.0	...	0.62	...	2.84	6.07	47	44
No. 46..	2	None	Calcium silicate sheet	31.1	0.89	0.89	2.29	31.1	...	0.72	...	1.23	3.52	16	18
No. 13..	1	A	Calcium silicate sheet	36.9	2.10	2.35	9.0	46.0	6.0–4.5	0.80	0.05	2.50	11.55	98	111
No. 21..	1	E	Calcium silicate sheet	23.0	0.75	...	...	...	...	0.67	...	1.12	...	...	...
			wood fiberboard	18.0	0.80	1.70	3.40	24.0	6.0–4.5	0.50	0.05	1.60	6.12	48	42
No. 22..	1	None	Calcium silicate sheet	36.1	1.05	...	...	...	...	0.85	...	1.23	...	...	...
			Calcium silicate block	14.4	1.05	2.10	4.38	25.1	...	0.44	...	2.39	8.00	73	64
No. 48..	1	A on hot face	Laminated asbestos felt	36.6	2.10	2.20	8.58	46.7	6.0	0.64	0.02	3.30	11.88	131	117
No. 49.	1	A	Laminated asbestos felt	34.5	2.18	2.29	8.50	44.5	6.0–4.5	0.64	0.05	3.41	11.96	122	119
No. 36..	1	None	Plaster board[d]	49.8	0.58	1.90	5.50	34.8	...	1.13	...	3.10	8.60	72	71
No. 38..	1	None	Plaster bd (2 3/8 in.)	48.0	0.75	0.75	3.00	48.0	...	1.13	...	0.64	3.64	24	19
No. 37..	1	A on cold face	Asbestos millboard	54.5	1.02	1.16	6.00	61.9	4.5	1.40	0.03	0.73	6.76	32	23B
No. 31..	1	None	Calcium silicate sheet	69.3	1.23	1.23	7.11	69.3	...	1.70	...	0.72	7.83	26	30B
No. 30..	1	None	Calcium silicate sheet	68.0	2.03	2.03	11.50	68.0	...	1.70	...	1.19	12.69	64	62B
No. 40..	1	None	Asbestos-cement sheet	119.2	1.48	1.48	14.70	119.2	...	5.8	...	0.26	14.96	34	32C
No. 44..	1	None	Asbestos-cement sheet	113.0	2.02	2.02	19.0	113.0	...	5.8	...	0.35	19.35	43	46C
No. 35..	1	None	Asbestos-cement sheet	119.0	1.00	1.00	9.90	119.0	...	5.8	...	0.17	10.07	17	17C

NOTE:

Furnace Designations
- *1*—2 by 2 ft
- *2*—4 by 8 ft
- *3*—1 by 1 ft
- *4*—7 by 7 in.
- *5*—4 by 5 ft

[a] At appropriate hot and cold face mean temperatures.
[b] At 500 F mean temperature except for multiple core materials.
[c] N = the sum of thermal resistance and weight in pounds per square foot.
[d] With aluminum foil faced inward on 3/4-in. air space.
[e] From curve *A* unless otherwise indicated.

Cover Designations
- *A*—1/8-in. asbestos-cement sheet
- *B*—Portland cement plaster
- *C*—1/2-in. asbestos-cement sheet
- *D*—7/16-in. calcium silicate sheet
- *E*—Wood veneer

pressed only in terms of thickness and density:

$$\log F = 0.41030 + 1.54244 \log \left[\frac{d}{10^{0.010\,\rho\, -\, 0.441}} + \frac{\rho d}{12} \right] \quad (5)$$

The form is, of course, somewhat awkward for general use. A better procedure might be to use the value of k predicted for the particular density. Thus, for a 2-in. thick, 35 lb per cu ft material, k = 0.86 and the expression becomes:

$$\begin{aligned} \log F &= 0.41030 + 1.54244 \log \left[\frac{2}{0.86} + \frac{35 \times 2}{12} \right] \quad (6) \\ &= 0.41030 + 1.54244 \log (2.32558 + 5.83333) \\ &= 1.81727 \\ F &= 65.656 \text{ or } 66 \text{ min} \end{aligned}$$

Comparison with Previous Work

Table II contains test results extracted from work reported elsewhere. It will be seen in Fig. 4 that the results given in references (**2**, **3**, and **6**) agree reasonably well with the curves derived from the present work. The results quoted in references (**4** and **5**) fall on lines differing, as might be expected, because of density.

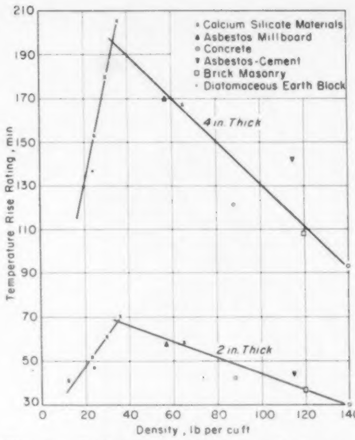

Fig. 3.—Relation of density and temperature rise rating for walls of equal thickness.

The indicated slopes are somewhat different, but the data are compatible with slopes similar to that derived here. Data presented in reference (**1**) agree in relation to density but show steeper slopes than the results reported here or in the other references.

Development of a General Prediction Formula

If the assumption of a similar power in the formula:

$$F = C \left(\frac{\rho d}{12} + \frac{d}{k} \right)^n \quad (7)$$

or in the logarithmic form:

$$\log F = \log C + n \log \left(\frac{\rho d}{12} + \frac{d}{k} \right) \quad (8)$$

is accepted for all densities, then the coefficient of the equation, C, will vary with density.

The curves drawn in Figs. 1 and 4 may be expressed as follows.

Density, lb per cu ft	Prediction Formula
10 to 50	$\log F = 0.410[illegible] + 1.5424 \log N$
55 to 70	$\log F = 0.095[illegible] + 1.5424 \log N$
110 to 120	$\log F = -0.3[illegible]56 + 1.5424 \log N$
120, brick	$\log F = -0.4478 + 1.5424 \log N$
140, concrete	$\log F = -0.6047 + 1.5424 \log N$

TABLE II.—MATERIALS AND FIRE RATINGS OF TESTS REPORTED BY OTHERS.

Source	Designation	Description	Panel: Thickness, in.	Panel: Weight, lb per sq ft	Panel: Bulk Density, lb per cu ft	Thermal Conductivity, Btu in. per hr sq ft deg Fahr	Thermal Resistance	N	Tested Rating, min	Estimated Rating: Min	Estimated Rating: From Curve[a]
BMS 123	1A	3/16 in.-asbestos cement on studs	4	3.13	68	6.0–4.5	0.95	4.08	10	11	B
BMS 123	2A	3/16 in.- asbestos cement and gypsum	4¾	6.25	59	6.0–4.5	1.60	7.85	64	62	A
BMS 92	Table 30	3/8 in.-Wallboard on 2 by 4 studs	4⅜	3.13	47	1.2–1.1 1.13	1.54	4.67	25	27	A
BMS 92	Table 30	½ in.-Wallboard on 2 by 4 studs	4⅝	4.17	47	1.3	1.79	5.96	40	[illegible]1	A
Underwriters' Laboratories	Class E-1 No. 5	5/8-in. Wallboard on 2 by 4 studs	4⅞	5.20	48	1.13	2.00	7.20	1 hr	55	A
Underwriters' Laboratories	Class D-2 No. 4	2⅝ in.-Wallboard on 2 by 4 studs	6⅛	10.40	49	1.13	3.10	13.50	2 hr	143	A
BMS 143	2	Common brick	3¾	37.5	120	5.5	0.68	38.2	80	100	D
BMS 143	12	Common brick	8	80	120	5.5	1.45	81.5	310	320	D
BMS 143	40	Common brick	12¼	123	120	5.5	2.23	125	619	620	D
BMS 143	27	Concrete brick	8	96	144	13.0	0.6	96.6	419	425	D
BMS 143	49	Concrete brick	12¼	147	144	13.0	0.9	148	827	800	D
ASTM Proc., Vol. 43, p. 1099	121	Concrete-siliceous gravel	4	47.1	141	13.0	0.3	47.4	66	67	E
	118	Concrete-siliceous gravel	6	69.6	139	13.0	0.5	70.1	150	151	E
	117	Concrete-siliceous gravel	8	91.4	137	13.0	0.6	92.0	273	273	E
	120	Concrete-siliceous gravel	6	70.2	140	13.0	0.5	70.7	158	155	E
	122	Concrete-siliceous gravel	6	70.5	141	13.0	0.5	71.0	143	155	E
	119	Concrete-calcareous gravel	4	48.9	147	13.0	0.3	49.2	82	73	E
	116	Concrete-calcareous gravel	6	74.1	148	13.0	0.5	74.6	196	175	E
	115	Concrete-calcareous gravel	8	98.9	148	13.0	0.6	99.5	331	325	E
	127	Concrete-calcareous gravel	6	76.6	153	13.0	0.5	77.1	181	185	E
	125	Concrete-Haydite	4	28.9	87	3	1.3	30.2	140	140	F
	124	Concrete-Haydite	6	43.1	86	3	2.0	45.1	383	398	F
	126	Concrete-Haydite	6	46.1	92	3	2.0	48.1	487	472	F
BMS 134	Table 2	Concrete-siliceous gravel	4	45.7	137	13.0	0.3	46.0	77	88	G
	Table 2	Concrete-siliceous gravel	4	45.7	137	13.0	0.3	46.0	81	88	G
	Table 2	Concrete-siliceous gravel	4	45.7	137	13.0	0.3	46.0	85	88	G
	Table 2	Concrete-siliceous gravel	5	57.2	137	13.0	0.4	57.6	120	121	G
	Table 2	Concrete-siliceous gravel	6	68.6	137	13.0	0.5	69.1	155	163	G
	Table 2	Concrete-siliceous gravel	6	68.6	137	13.0	0.5	69.1	169	163	G
	Table 2	Concrete-siliceous gravel	8	91.5	137	13.0	0.6	92.1	287	271	G
	27A	2½ in. concrete and ¾ in. gypsum	4	32.5	111	13–1.1	0.9	33.4	81	...	...

[a] See Fig. 4.

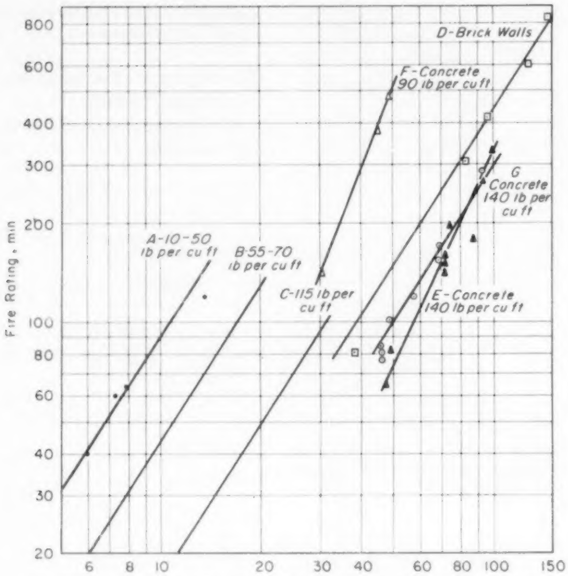

Fig. 4.—Comparison of present and reported results.

The above formulas were solved for the coefficient C. Plotting log C against density indicated a relationship expressed by the equation:

$$\log C = 0.692 - 0.0093\,\rho \ldots\ldots (9)$$

Substitution of this relationship in the prediction equation leads to a generalized formula of:

$$\log F = 1.5424 \log \left(\frac{d}{k} + \frac{\rho d}{12}\right) + 0.692 - 0.0093\,\rho \ldots\ldots (10)$$

This gives a formula for prediction of time for temperature rise based only on wall thickness, density, and thermal conductivity at 500 F mean temperature. Comparison of predicted ratings with test ratings may be seen below:

From the table it may be seen that the generalized prediction formula appears to be useful for prediction of time ratings for walls formed of nonfibrous material over 20 lb per cu ft in density. For such materials the possible error ranges up to 10 per cent.

Conclusions

1. Temperature-rise fire ratings of materials and combinations of materials can be estimated from density and thermal conductivity by the methods described in this report.

2. The optimum density of insulating materials to be used for fire walls appears to be in the range 30 to 40 lb per cu ft. This appears to be related to the density-thermal conductivity relationship noted and to the effect of heat capacity.

3. Low-density fibrous materials are inferior for use in fire walls. It seems probable that a major factor in this inferiority is the presence of convection currents within the material during the course of fire exposure.

4. Materials containing an appreciable amount of combustible material fall short of the rating which would be expected. This is believed to be due to release of additional heat by the exothermic reaction in the material.

5. Materials which undergo an endothermic reaction during fire exposure will show a rating higher than other materials of comparable density.

6. For materials of a density greater than 100 lb per cu ft the thermal transmission factor becomes of minor importance and fire rating predictions may be made on the basis of weight per square foot only.

7. It appears from the stud wall tests that the calculation of bulk density should include only the volume of the solid materials and not the air spaces. It is presumed that the insulating value of the air space is decreased due to the high temperatures encountered. Radiation effect is increased and convection currents may be increased. Low emissivity surfaces facing air spaces of reduced thickness may not follow this assumption (see test No. 36).

8. The method of prediction presented may also be applicable to floors or ceilings. Note that the results on concrete floors presented in reference (**4**) are compatible with those reported for vertical slabs in reference (**1**).

9. Study of additional data is necessary to carry forward the method of prediction. With sufficient data, it may be possible to develop more accurate coefficients and to expand the method to include fibrous materials. With adequate thermal data it may also be possible to develop rational prediction equations for walls of materials ranging from fibrous insulations to steel.

Test	Material	Rating, min		Error	
		Predicted	Tested	Min.	Per cent
No. 1	calcium silicate, 12 lb per cu ft	77	51	+26	+51
No. 10	calcium silicate, 25 lb per cu ft	64	67	−3	−4
No. 13	calcium silicate, 37 lb per cu ft	98[a]	98	0	0
No. 22	calcium silicate, 14 and 36 lb per cu ft	71[b]	73	−2	−3
No. 30	calcium silicate, 68 lb per cu ft	58	64	−6	−9
No. 44	asbestos cement, 113 lb per cu ft	42	43	−1	−2
No. 45	felted mineral fiber (4 lb per cu ft) with calcium silicate covers	51[c]	62	−11	−18
No. 143-12	brick, 8 in.	335	310	+25	+8
No. 134-7	concrete, 8 in.	280	287	−7	−2

[a] Based on core density.
[b] Based on average density.
[c] Based on cover density.

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(**1**) C. A. Menzel, "Tests of the Fire Resistance and Thermal Properties of Solid Concrete Slabs and Their Significance," ASTM *Proceedings*, Vol. 43, p. 1099.

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Mooney Cure Tests for Calculating Curing Times[1]

By A. E. JUVE

THE usefulness of the data obtained in a Mooney cure test beyond the scorch time as a measure of the rate of cure has been recognized for some time (**1**, **2**, **3**).[2] The usefulness of the data in setting an "optimum" or "equivalent" curing time was suggested by the author in a communication to the Office of Rubber Reserve in 1945 and was also suggested by him in the chapter on Physical Test Methods in *Synthetic Rubber* (**4**). In this reference it was stated that ". . . . the time required to reach the approximate optimum could be calculated from the Mooney cure data by assuming that this time is made up of the scorch time and the product of a constant and the time required for the viscosity to increase above the minimum viscosity a fixed number of units." The equation suggested at that time was:

$$\text{Curing time} = T_s + 6T_{\Delta 30} \qquad (1)$$

where:

T_s = the scorch time based on the last lowest viscosity reading preceding a consistent rise in viscosity, and

$T_{\Delta 30}$ = the time required for a rise of 30 units beyond this point. All tests at that time were run using the small rotor.

For reasons which will be discussed later, this equation has been revised slightly. This suggestion was based on the simple argument that the time to reach an "optimum" cure is dependent on the length of the induction period, which is measured by the scorch time, and some function of the rate of cure after cure begins. The rate of cure in this case is measured by the rapidity with which the viscosity increases an arbitrary number of units beyond the scorch point.

ASTM Method D1077 for determining the curing characteristics of vulcanizable mixtures during heating by the shearing disk viscometer[3] is in the process of general revision, one part of which will be to include procedures for abstracting cure rate information from the cure curve.

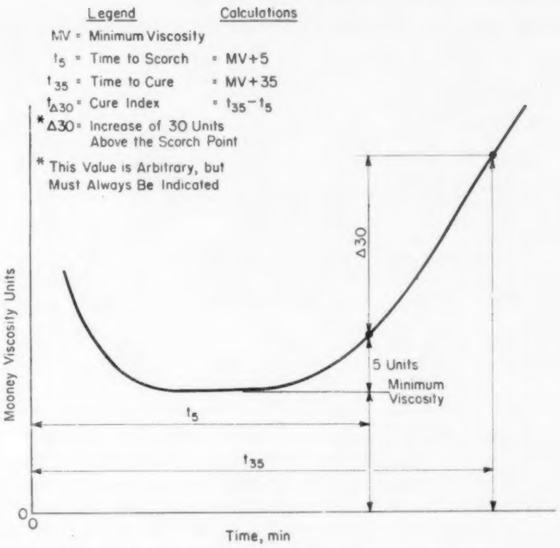

Fig. 1.—Typical cure curve for the proposed revision.

A typical cure curve for the proposed revision, together with the conventions for reporting the data are shown in Fig. 1. This illustration differs from that in the present method in that the cure rate factor is shown as the time required for the viscosity to increase 30 units beyond the scorch time. The cure rate is indicated by this time and may be reported as the average viscosity increase, in Mooney units per minute, during this period.

Sensitivity and Reproducibility of the Test

A test method for measuring the cure rate must be sensitive to small differences in cure rate to be acceptable. It must at the same time be reproducible.

The simplest way to demonstrate the sensitivity is to make systematic changes in a composition which it is known will change the cure rate and by means of the Mooney cure test determine the response of the test to these changes. We ran one such test some years ago on an SBR stock that was accelerated with *N*-cyclohexyl-2-benzothiazolesulfenamide and activated with 0.25 parts per hundred parts of rubber (phr) of an aldehyde-amine accelerator. Tests were run on the normal recipe and with two modifications in which the aldehyde-amine was increased by 0.05 parts and decreased by 0.05 parts. The uncured stocks were stored at constant humidity, and daily tests were run for 12 working days. The results are summarized in Table I.

A further study of the same composition in which the aldehyde-amine accelerator was varied from zero to 0.40 phr provides additional data. These tests were run at both 280 F and 300 F; the data are shown in Fig. 2. The regularity of the relationship found is good evidence of the sensitivity of the test.

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[1] Presented before Committee D-11 on Rubber and Rubber-Like Materials in Pittsburgh, Pa., Feb. 6, 1959.

[2] The boldface numbers in parentheses refer to the list of references appended to this paper.

[3] 1958 Book of ASTM Standards, Part 9, p. 1163.

TABLE I.—EFFECT OF SMALL CHANGES IN CONCENTRATION OF SECONDARY ACCELERATOR.

Aldehyde-amine concentration, phr	0.20	0.25	0.30
Average of 12 tests, min[a]	7.6	6.31	5.4
Standard deviation, min	0.3	0.23	0.11

[a] Time for viscosity to increase 20 units beyond minimum.

TABLE II. EFFECT OF TEST TEMPERATURE ON REPRODUCIBILITY.

Test Temperature	248 F		284 F		320 F	
	Avg Time	σ	Avg Time	σ	Avg Time	σ
(A) t_5, min	23.93	1.27	7.13	0.342	3.59	0.122
$t_{\Delta 30}$, min	6.29	0.685	1.65	0.186	0.585	0.072
(B) t_5, min	24.4	0.31	7.51	0.136	3.63	0.023
$t_{\Delta 30}$, min	6.46	0.536	1.59	0.134	0.52	0.040
(C) t_5, min	19.61	1.14	5.24	0.263	2.64	0.115
$t_{\Delta 30}$, min	12.13	1.05	2.07	0.137	0.695	0.038

TABLE III.—CORRECTION FOR LAG TIME.

Test Temperature, deg Fahr	t_5, min	t_5 Corrected, min	$t_{\Delta 30}$, min	$t_{\Delta 30}$ Corrected, min
240	33.8	30.5	7.4	7.4
260	16.0	12.7	3.6	3.6
280	8.4	5.17	2.12	2.05
300	5.27	2.53	1.25	1.02

A paper (5) on the effects of moisture on the rate of cure of guayule in a modified American Chemical Society recipe lends some support to the claim that this is an exceedingly sensitive test for cure rate. The essential data are shown in Fig. 3. The marked dependence of cure rate and scorch time on moisture content are well illustrated. The moisture contents were determined analytically.

In another study designed to obtain a measure of reproducibility, three different stocks were tested at each of three test temperatures twice weekly for ten weeks. A summary of the results is given in Table II.

Temperature of Test

The temperature of the test may be varied over a wide range with reliable and reproducible results. For practical purposes it is well to use a temperature that does not result in too long a test time.

A complication enters, however, when tests are run at different temperatures. This is the result of the lag time in heating the relatively thick Mooney specimen to the test temperature. The lag time does not decrease with an increase in the test temperature and it becomes a larger and larger proportion of test time as the latter decreases. Figure 4 shows a correction curve for this lag time plotted as effective time against elapsed time. This was constructed by integrating the curing effect during the heating part of the cycle in which it was assumed that cure rate doubles for an 18 F increase in temperature. This curve was based on stocks containing about 50 phr of carbon black. Stocks with different thermal properties would be expected to behave differently. A gum stock, for example, would have a somewhat greater lag than is indicated by this curve. There may also be minor differences between different models of the viscometer and with different methods of heating.

An indication of the magnitude of this effect is shown in Table III.

If, for example, one wishes to determine the temperature dependence of cure and scorch rate, it is essential that this correction be made. Fig. 5 shows a plot of the effects produced by the addition of a series of retarders to a natural rubber stock accelerated with MBT. This figure is interesting not only in showing how well the corrected Mooney curve data fit on a plot of this kind but also in showing the lack of basis for the oft-repeated claims that retarders are effective in reducing scorching tendencies at processing temperatures but do not slow down the rate of cure at curing temperatures.

For our particular interest at the moment, it will be immediately apparent that in calculating the cure time using the suggested equation, an appreciable error would be introduced if one is comparing a pair of stocks, one of which cures quickly and the other slowly.

Calculation and Correlation with Stress-Strain

Equation 1, as described above, was based on a different convention for designating scorch time and on the use of the small rotor instead of the large rotor. The use of the small rotor gives a numerically smaller viscosity value than the large rotor for the same material. The ratio is approximately 1.7, that is the viscosity reading obtained with the small rotor multiplied by 1.7 will give the large-rotor value. Thus to obtain concordant results on the two rotors in a cure test, the scorch time for the small rotor should be taken at 3 units above the minimum instead of 5 and the rise beyond the scorch point should be 18 instead of 30. This ratio of large-rotor values to small-rotor values is not constant for all stocks and will vary slightly from one material to another due to the different response of different materials to variations in the shear rate.

Because of these two points—the use of a different scorch point and the use

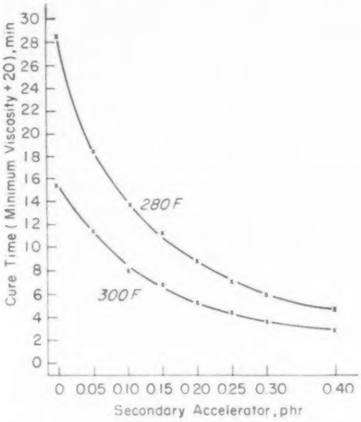

Fig. 2.—Data for tests run at 280 F and 300 F.

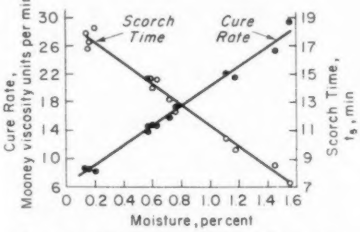

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Fig. 3.—The effects of moisture on the rate of cure of guayule in a modified MACS recipe.

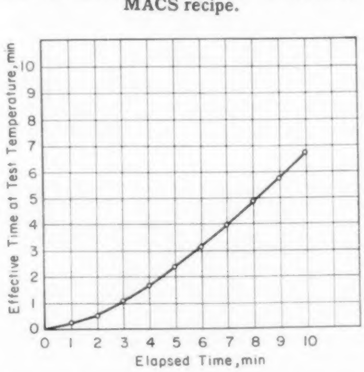


Fig. 4.—Correction curve for thermal lag.

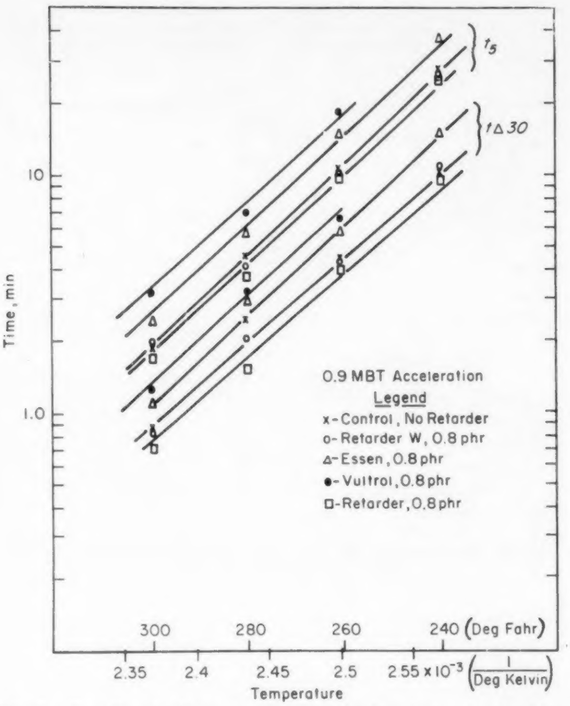
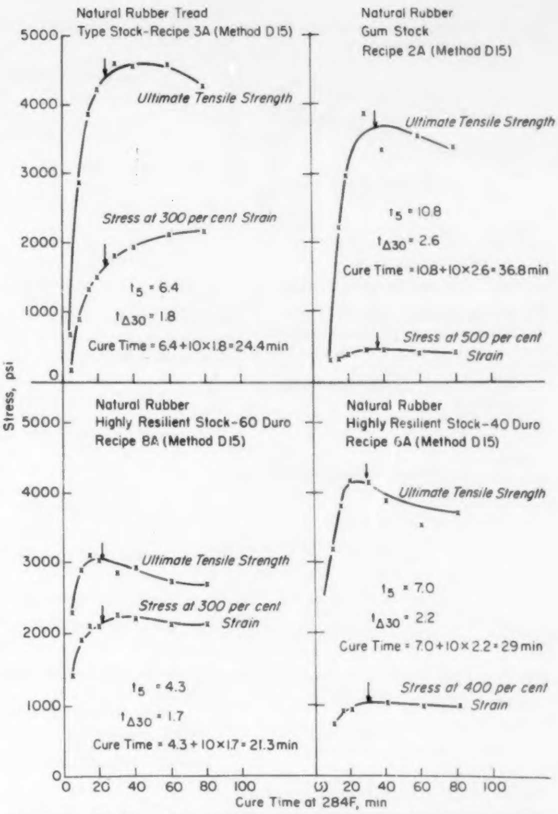


Fig. 5.—Results of adding a series of retarders to a natural rubber stock accelerated with MBT.



Figs. 6.—Test results showing relationship of stress-strain data and Mooney cure test data.

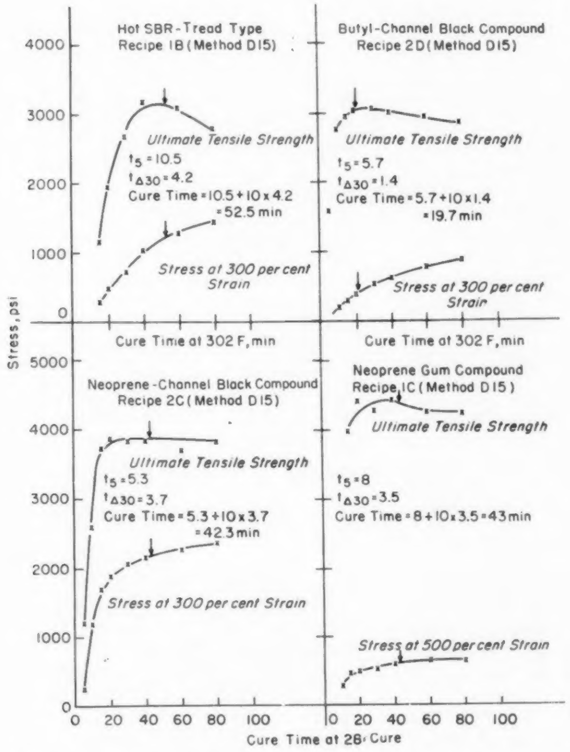


Fig. 7.—Test results showing relationship of stress-strain data and Mooney cure test data.

of the large rotor (which we recommend for all except very stiff stocks)—Equation 1 has been modified to use a factor of 10 instead of 6.

These factors were selected on the basis that they fit, fairly well, the selection of optimum cure from stress-strain data considering both ultimate tensile strength and development of modulus. However, there is nothing absolute in these factors and if one wishes, higher or lower values may be used.

As illustrations of how the calculated cure time from Mooney data corresponds to stress-strain data, a number of the formulations from Method D 15[4] were tested both in the Mooney cure test and by stress-strain. The results obtained are shown in Figs. 6 through 10. On the basis of these data, which include stocks based on natural rubber, SBR, butyl, and neoprene, the agreement between the calculated cure time and the cure one would select from stress-strain data is remarkably good.

In some cases one is dealing with a stock which is said to have an optimum cure based on some property other than

[4] 1958 Book of ASTM Standards, Part 9, p. 1225.

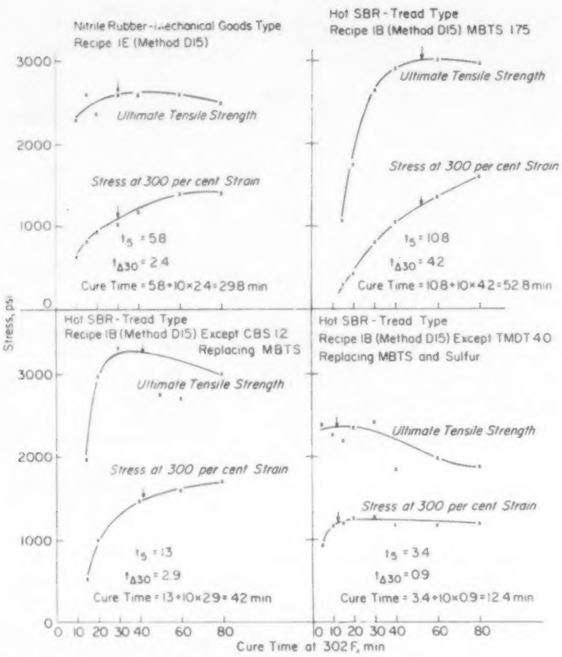


Fig. 8.—Test results showing relationship of stress-strain data and Mooney cure test data.

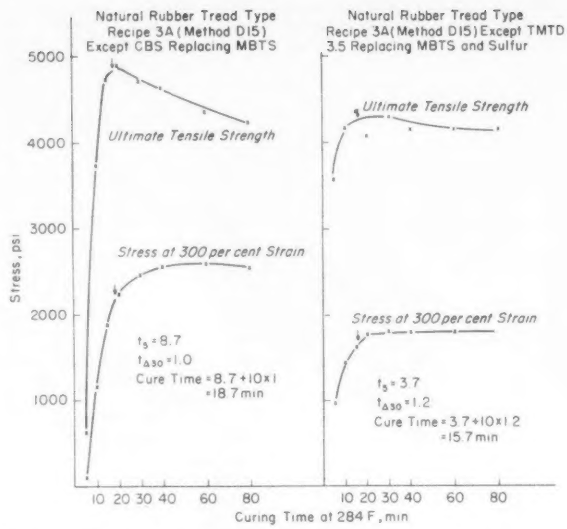


Fig. 10—Test results showing relationship of stress-strain data and Mooney cure test data.

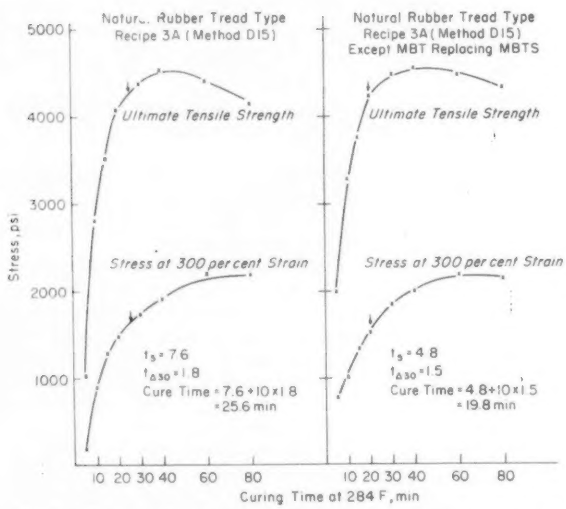


Fig. 9.—Test results showing relationship of stress-strain data and Mooney cure test data

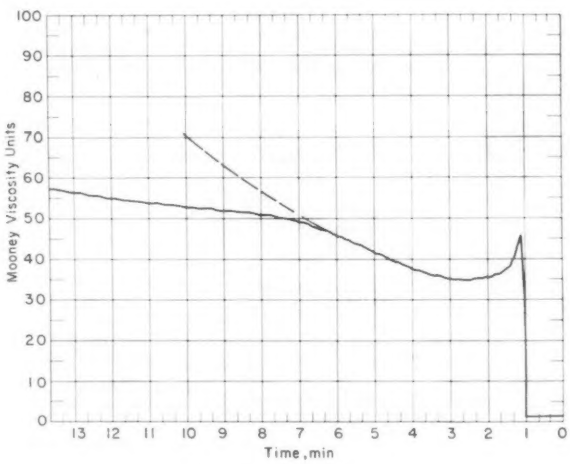


Fig. 11.—An abnormal Mooney cure curve.

stress-strain. In these cases the Mooney cure test can be used to judge the effects of compound variations by first determining what factor in the formula will give the accepted value for optimum cure. Thus if a stock is said to have an optimum cure of 40 min at 280 F and one or more Mooney cure tests have been run on it, one can can calculate a value for A as follows.

$$40 = t_5 + At_{\Delta 30} \quad (2)$$

To recapitulate:

1. The large rotor should be used whenever possible.

2. A factor of 10 for the factor A will generally give good correlation with the selection of optimum cure from stress-strain *versus* time of cure considering both tensile strength and modulus development.

3. For comparisons involving both fast and slow curing stocks or different temperatures, it is advisable to use the correction curve shown in Fig. 4. The value of the factor A need not be changed.

4. If the value of 10 does not give good correlation with the selection of optimum cure, one can calculate a factor that will. This can then be used for subsequent studies.

We have not studied in a systematic way all vulcanizing systems or all polymers. As far as we know, all that we have tried respond in the same way. If one varies the curing system in a single stock so that the cure rate is

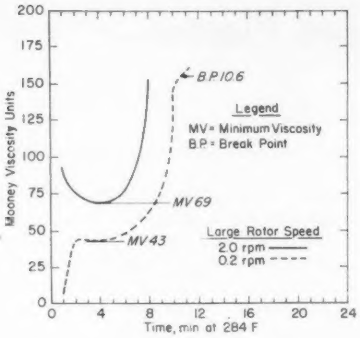


Fig. 12.—NR tread type, recipe 3A (Method D15)

changed over a wide range, the calculated cure time will not give equal modulus. This is because the state of cure will of necessity vary as well as the rate of cure. A possible explanation for the consistently good results obtained by this procedure is that the calculation gives a cure time at which a definite proportion of the curing effect has been exhausted.

Possible Difficulties with the Method

One essential requirement of the method is that the viscometers on which the tests are run be maintained in good working condition. If this is not done, the results obtained will be unreliable. A prime requisite is that the machines be equipped with thermocouple junctions extending into the specimen so that the actual temperature of the stock (or of the cavity before the stock is inserted) is measured.

It is worth mentioning that as far as the cure characteristics are concerned the machine need not be in calibration since it is only the shape of the curve that is of concern. Displacement up or down will not affect the values scaled from the curves. However, if one is using this method for control purposes, the value of the minimum viscosity is also of importance.

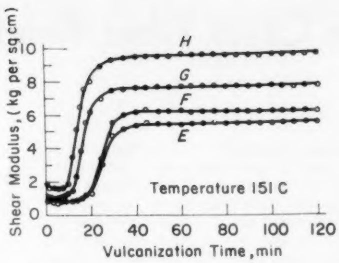
It should be obvious that any error in the determination of $t_{\Delta 30}$ is multiplied by about 10 in making the calculation of curing time. Occasionally, one will see a curve that rises irregularly. This is usually due to crumbling of the stock. In fact all such curves will eventually fall off because when the stock reaches a sufficiently high state of cure it must, of necessity, tear. Figure 11 illustrates a curve in which this occurred at an early stage. When this occurs, the portion of the curve beyond the point of irregularity should be ignored. Usually one can extrapolate the regular portion of the curve far enough to reach the point of 30 units above the scorch point. If this cannot be done the test should be rejected and re-run.

To determine if the curve is irregular, one should have either a curve produced on a recorder or the actual data taken by the operator, which should be plotted for inspection.

From what has been said, it should be apparent that the Mooney cure test covers only the beginning of the cure cycle. It ends at about the time the cure has reached the point where a measurable modulus is apparent. If it were not for the fact that the test is quite reproducible, this would be a serious weakness.

It was suggested that perhaps the time before crumbling occurs could be extended by operating the rotor at an appreciably slower rate. Tests run at 0.2 rpm instead of 2 rpm show that this can be accomplished. However, the time is extended only a little so that not much is gained. Figure 12 shows a pair of curves for a natural rubber tread-type recipe run at both 2 and 0.2 rpm.

A method of following the entire cure cycle has been proposed very recently by workers in Germany (**6**). This involves sandwiching a metal paddle between two flat specimens of the uncured rubber, the other surfaces of which are in contact with heating platens. The paddle is moved back and forth continuously at a frequency of 0.5 cps and with an amplitude of 0.25 mm. The force required to do this is recorded and plotted as a function of the time of heating.



Courtesy of Rubber Chemistry and Technology

Fig. 13.—Curves of stocks based on SBR.

Figure 13 shows a series of curves of stocks based on SBR. E is an unloaded stock, F contains 50 phr of barytes, G contains 50 phr of a coarse black, and H has 50 phr of HAF black. Figure 14 shows cure curves based on natural rubber which illustrate reversion. B is a stock containing 2.5 phr of sulfur and 50 phr of barytes, M contains 3.5 phr of sulfur, and N has 4.5 phr of sulfur.

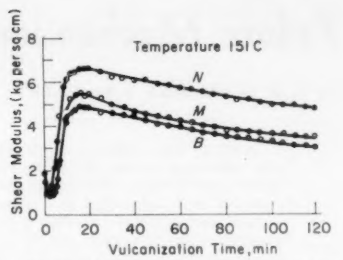


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Fig. 14.—Cure curves based on natural rubber which illustrate reversion.

Summary

The Mooney cure test is a sensitive and reproducible test for measuring the delayed-action portion of the cure and for measuring the rate of cure in the early part of the cure. From these data one can calculate an approximate optimum cure for a particular stock or equivalent cure times for different stocks.

Because the test involves only the early part of the cure period, it is necessary to exercise care in assuring that accurate measurements are obtained. The most common difficulty is that the viscosity curve in some cases exhibits an irregular rise due to partial crumbling of the stock.

In some instances, when fast-curing stocks are compared with slow-curing stocks or when tests are run at different temperatures, the correction for time lag in attaining the test temperature becomes important.

It would be desirable if the important features of the Mooney cure test, a continuous measurement as cure progresses on a single specimen of stock at the curing temperature, could be extended to cover the entire curing range.

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Failure Mechanisms in Glass Fiber Reinforced Plastics

By M. B. DESAI and F. J. McGARRY

In glass fiber reinforced plastic laminates, internal cracking under tensile stressing takes place because of yarn crimp resulting from fabric weave and because of resin tensile and shear brittleness. This effect is recognized and measured by water absorption determinations carried out subsequent to tensile loading cycles. It does not occur under compressive loading. The cracking can be prevented by the use of no-crimp fabrics, if loaded in a principal direction, or by the use of more ductile resins. The technique of observation provides a valuable tool to study the three-dimensional and interlaminar characteristics of such composite structures.

PREVIOUS work[1] has associated an internal cracking action of glass fiber fabric reinforced laminates with some of the curious tensile characteristics which these materials often exhibit. Most notable among the latter is the "knee" or sharp modulus transition found with many laminates during their first loading to any appreciable stress level. This transition has been associated with an internal cracking by making water absorption measurements on tension specimens stressed beyond such levels and comparing their weight gain after immersion to identically exposed specimens which had undergone no tensile stressing; the stressed or previously loaded specimens consistently demonstrated a significantly greater moisture absorption. It was felt that such a simple yet sensitive technique would be useful in the study of fabric and resin actions and interactions in laminate behavior and could be employed to improve our understanding of composite materials generally. For example, the effects of fabric weave, glass surface finish, resin properties, curing conditions, and other parameters could be economically and informatively studied, both qualitatively and quantitatively in this fashion, since an important criterion of any composite structural material is its retention of physical continuity under stressing. For these reasons a somewhat more extensive study was undertaken and constitutes the subject of this paper.

The resin commonly used in laminates—polyester, epoxy, phenolic, or some other—is notable for its comparatively low modulus, intermediate strength, and lack of ductility under tensile or shear stresses; it fractures at low strain levels. Since glass filaments are much stiffer and stronger and exhibit approximately the same ductility, initial impressions suggest that the two should function effectively when combined. This is true unless the glass is woven into a fabric, where the yarns are bent as they pass over and under each other. Under such circumstances the stiffness of the primary structural element, the fabric, is much less than that of the filamentous glass and when loaded in tension, a straightening of the yarns occurs, imposing very high tensile and shear strains on any surrounding attached matrix, in this case, the binding resin. These high local displacements, combined with the Poisson contractions of the resin, cause fractures of the resin since it is a brittle material. This is illustrated, in a simplified fashion, in Fig. 1, which presents two related mechanisms possibly responsible for the cracking behavior. Which of the two is the more correct necessitates further experimental study. Conversely, compressive loading does not exhibit such an effect since the elastic resin matrix effectively supports the yarn against local buckling and also expands against the yarn, again because of the Poisson action.

To test the validity of the foregoing hypothesis, moisture absorption measurements after stressing can be used. If the reasoning is correct, a number of observations should be possible:

1. Compressive stressing, irrespective of the fabric weave, should show no differential moisture absorption effects.

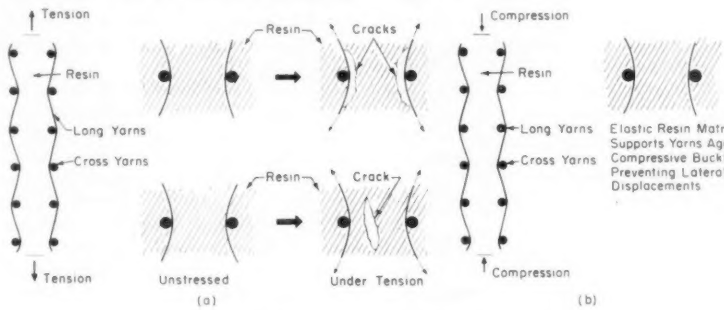

Fig. 1.—Hypothesis for failure mechanisms.

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[1] R. E. Chambers and F. J. McGarry, "Tensile and Compressive Properties of Fiberglass Reinforced Laminates," ASTM BULLETIN, No. 233, p. 41 (Oct., 1958).

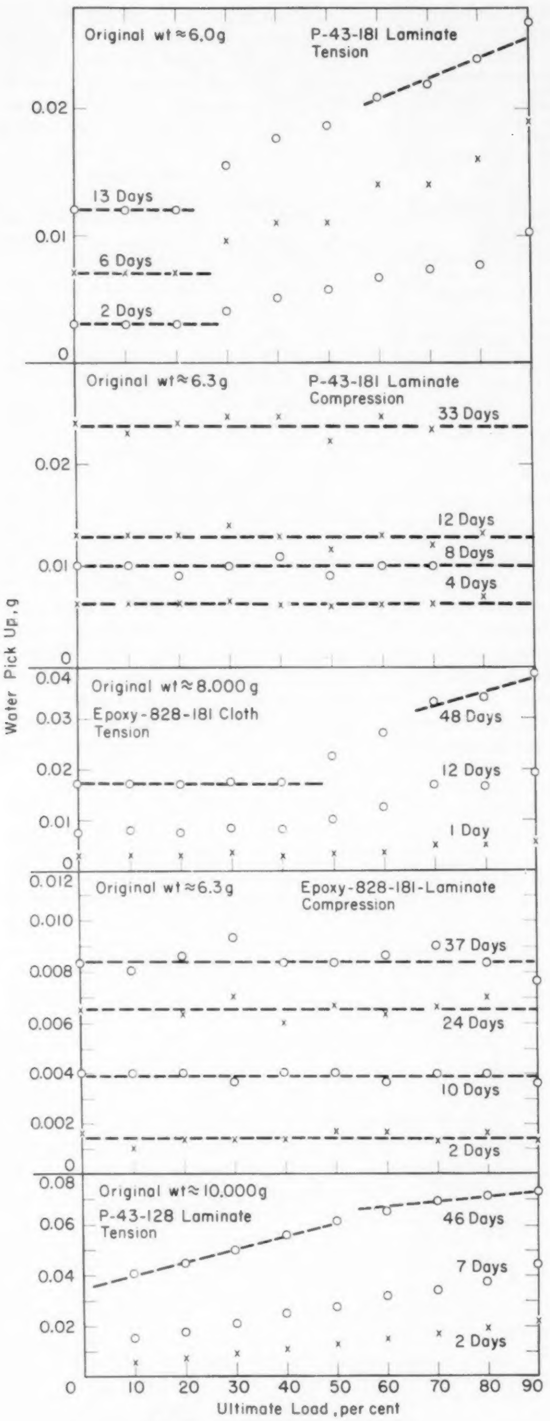

Fig. 2.—Water absorption tests.

2. A no-crimp fabric having no cross yarns, should show no differential absorption under tensile stressing.

3. A fabric with cross yarns should differentially absorb water after tensile stressing, probably as a direct function of the level of stress imposed upon the sample.

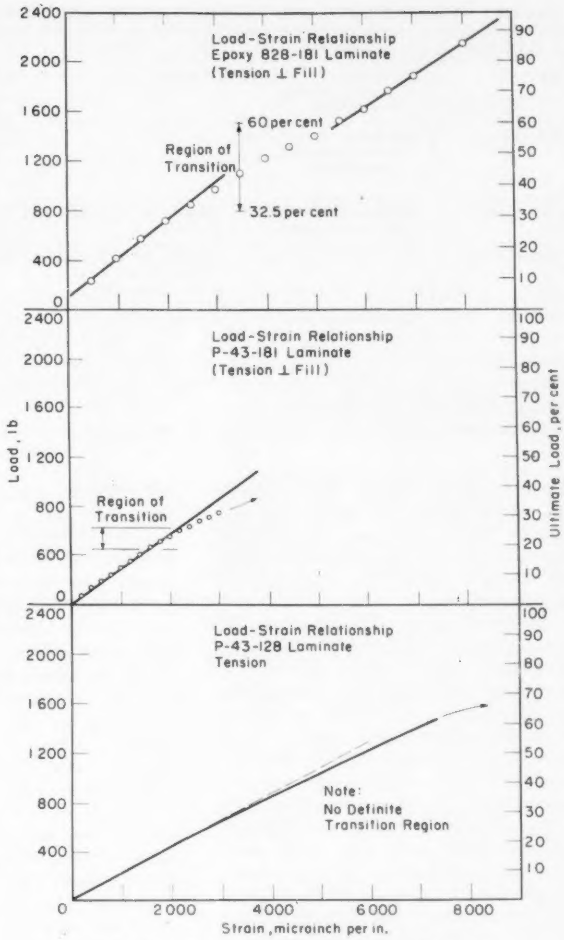

Fig. 3.—Tensile load-strain relationships.

4. A high-ductility resin, capable of large extensions prior to fracture, should make a crimped yarn fabric behave under tension, like a unidirectional one: no differential absorption.

5. If a knee in the tensile stress-strain curve is truly a reflection of internal fractures, then the moisture absorption effect should also exhibit a discontinuity in the same stress region.

Finally, it has been conjectured that one possible effect of glass surface finishing agents is to impart local ductility to the resin near the glass surfaces in a laminate, thus enhancing the laminate's resistance to moisture-induced strength degradation. The procedure followed in this study should establish the plausibility of this idea, also.

Procedure and Results

The components and fabrication of the various laminates used are presented in Table I. After preparation of the laminates, parallel edge tension specimens, approximately 9 in. long, $\frac{1}{2}$ in. wide, and $\frac{1}{8}$ in. thick, and compression specimens, $1\frac{1}{4}$ in. long, $\frac{1}{2}$ in. wide, and $\frac{1}{4}$ in. thick, were machined from each and divided into groups of three for replication purposes. The first two groups from each laminate were tested to destruction to establish the tensile and compressive strengths; a second pair of groups from each were not tested, to serve as unstressed controls. Then, successive groups were individually

TABLE I.—COMPONENTS AND FABRICATION OF EXPERIMENTAL LAMINATES

Laminate	Fabric	Resin	Cure
P43-181	181-Volan A; 12 plies, tension; 24 plies, compression	Paraplex P43[a]	0.5 per cent benzoyl peroxide. 25 psi at 180 F for 6 hr. Press cooled.
828-181	181-Volan A; 14 plies, tension; 26 plies, compression	Epon 828[b]	14 pphr CL. Vacuum bag. Post cure 2 hr/150 C and 1 hr/200 C. Oven cooled.
Scotch ply[c]	12 plies unidrectional, parallel laminated	Preimpregnated with Epoxy	25 psi 330 F, 35 min. Press cooled.
P43-P13-181	181-Volan A; 12 plies	50 per cent Paraplex P43; 50 per cent Paraplex P13	0.5 per cent benzoyl peroxide 25 psi at 180 F for 6 hr. Press cooled.
P43-128	128-Volan A; 12 plies	Paraplex P43	0.5 per cent benzoyl peroxide. 25 psi at 180 F for 6 hr. Press cooled.

[a] Rohm & Haas Co., Phila., Pa.
[b] Shell Chemical Corp., New York, N. Y.
[c] Minnesota Mining & Manufacturing Co., St. Paul, Minn.

tested, with a single loading cycle, to 10 per cent, 20 per cent, 30 per cent, etc., up to 90 per cent of the ultimate strengths previously established. After the loading cycles were completed, the tensile specimens were further machined to the same sizes and shapes, by simple cutting, to remove the grip-damaged ends. Finally, all of the specimens were carefully weighed and then immersed in vessels containing room-temperature tap water, to be periodically removed, wiped surface-dry and reweighed, to measure moisture absorption. By this procedure, the data presented in Fig. 2 were obtained; as mentioned previously, each point represents an average of three specimens, the scatter being extraordinarily small. Figure 3 shows tensile load-strain curves for these laminates and it is seen that when a discontinuity is present in them, it is also present in the tensile preloading-moisture absorption curves.

In Fig. 4 a unidirectional Scotch-ply based laminate having essentially no cross fibers, no effect of tensile preloading on subsequent moisture absorption is evident and no internal cracking occurs, as is also clear from the very linear stress-strain behavior of this laminate in tension. Finally, Fig. 4 also presents a 181-fabric laminate, but in this case the laminating resin is a blended one, much less rigid than the P-43 previously used and capable of approximately 75 per cent extension prior to tensile fracture. It is seen that this material, definitely nonlinear in tensile stress-strain behavior, shows no evidence of the progressive internal fractures under discussion. Gross local distortions of the resin, imposed upon it by the displacements of the yarn, are successfully sustained and the composite retains its continuous integrity.

Discussion

It is felt that the results of this study well support the hypothesis earlier presented: local yarn displacements caused by tensile stressing of laminates produce fine internal cracks because of resin brittleness. This cracking can be prevented by either fabric or resin selections on the proper bases. It does not appear to be prevented by finishing agents since that one used on the woven fabrics, Volan A*, is generally recognized as being one of the best presently available. Parenthetically, it should be pointed out that such a conclusion more clearly defines, by elimination, the possible mechanism by which such agents contribute beneficially to laminate properties: either through better wetting-out of the fabric by the liquid resin or by producing an improvement in the glass-resin joint strength by physical-chemical actions still awaiting clearer proof.

Laminate design and analysis will remain at the present inexact level until we understand how to take validly into consideration the properties and behavior in the direction perpendicular to the plane of the laminae and treat the material as three-dimensional. Though perhaps more qualitative than quantitative for this purpose, the technique of moisture absorption measurement after tensile preloading is felt to be of significant value in that it makes simply possible a method for studying various resins, fabrics, and other variables from the viewpoint of laminate durability under stressing.

In many applications including boats, aircraft, and missiles, it is highly desirable that the glass fiber reinforced laminates do not degrade structurally under the action of applied loads. To avoid gross failures and for design economy, usually resins which produce high-modulus, high-strength laminates are selected. Thus far, resin technology can meet these demands only with resins that are brittle as well as comparatively strong and stiff; it is felt that our results forcefully demonstrate the value of ductile resins, capable of appreciable extensions prior to tensile or shear fractures. Only in this way can economical reinforcing fabrics be used for uncoated laminates possessing sustained operational stability with resistance to the moisture penetration so deleterious to mechanical and electrical properties.

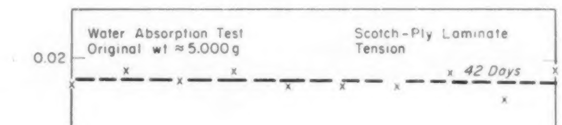

Fig. 4.—Water absorption tests.

* E. I. du Pont de Nemours & Co., Wilmington, Del.

Acknowledgment

This work was performed in the M.I.T. Plastics Research Laboratory, A. G. H. Dietz, Director, which is supported by a Grant-in-Aid from the Manufacturing Chemists' Assn., Inc. The reinforced plastics research program has been supported by funds received from the National Science Foundation, Owens-Corning Fiberglas Corp., Shell Chemical Corp., and Pittsburgh Plate Glass Co. The assistance of James E. Carey, Shell Chemical Corp., and Arthur L. Smith and William G. Carson, Rohm & Haas Co., in providing some of the laminates used in this study is appreciated.

Discussion of Paper on False Negative Permanent Strains Observed with Resistance Wire Strain Gages[1]

MR. PETER STEIN[2] (*by letter*).—It is rare indeed that a researcher in one field takes time out to investigate a phenomenon which puzzles him and which is in an essentially nonrelated field; that this investigation is as thorough as the author's is also infrequent under those circumstances.

As a consequence it is therefore not too surprising that the specialized literature of the strain gage field was either not known or not available to the author at the time of his investigations, and I am taking the liberty of summarizing recent work in the area of load-induced zero-shifts and of calling attention to several recent papers (**1–5**)[3] dealing with stresses in the adhesive layer of a strain gage installation, with cellulose nitrate cements, and with constantan alloy, all considered specifically from the point of view of strain gage application. After all, Campbell's paper (reference (**1**) of the paper) which is the only original research to which the author refers, is 15 yr old now, although it is still the bible of all strain gage researchers—but more has been done in the intervening years. Abstracting a dozen or so articles which appeared in 1958 in the periodical *Strain Gage Readings*, present knowledge is about as follows:

Cellulose nitrate cements[4] set by means of solvent evaporation. Up to 80 per cent of the adhesive weight may evaporate during cure, hence a path *must* be left for solvent exit during cure. The evaporation process leaves behind a rather complex and serious condition of residual stresses within the matrix of the gage carrier and in the adhesive layer between the gage and the test specimen. During solvent evaporation, time-dependent strains are set up in the gage grid; these have been monitored by a number of investigators.

The cure of the cellulose nitrate cement progresses for a long time after the gage is apparently ready for service, and continued no-load zero-shifts may be observed for 10 days if room-temperature cures are used. For long-term or precision tests, the cellulose nitrate cements, if they are used for strain gages (actually the phenolic bakelite adhesives are superior for such tests) must be cured at 140 F for as long as it takes the gage-to-specimen electrical resistance to reach 10,000 megohms (12 to 24 hr). A 1-hr post-cure at 160 F relieves the residual stress condition set up during curing, and that should be followed by immediate application of waterproofing wax. Under curing conditions such as these, no detectable zero-shifts occur, and even long-term creep behavior is excellent. To those familiar with the field, the figure of a total of 75 microinches per in. creep strain for an A-7 paper gage mounted in accordance with the above process and subjected to 2900 microinches per in. strain in tension for 60 days may show how efficient this mounting procedure is; it was originally recommended by McWhirter at Sandia and is referenced in the *Strain Gage Readings* articles listed below.

The choice of gage grid configuration and size will affect the load-induced zero shift, and the author's choice of a flat-grid, coarse-pitch, long gage for his studies is the very best that could have been made in a paper gage, although the new foil-type paper gages would probably have shown superior results. It has also been shown that *always*, a constantan-type gage mounted with cellulose nitrate cement will produce a zero-shift ***opposite in sign*** to the applied load, so that all the author's results are consistent with past experience in this field. (Note that the steel actually did show a zero-shift itself as shown by the optical strain gage data presented by the author. Thus, relative to the actual specimen, the strain gage creep was always opposite in sign to the applied load.)

It may be interesting to note that it has been shown that a gage load-cycled in compression only, for example, behaves worse on its first tension cycles than if it had never been load-cycled at all. Thus the *direction* of cycling is critical. The enclosed papers show numerous data from past investigators on this effect, the effect of the number of load cycles and of drying time on zero-shift, etc.

In addition to zero-shift, the gage installation will exhibit hysteresis in its behavior, and it would be most interesting to hear if the author has accumulated data on this relatively unstudied phenonenon.

A fairly lengthy article is to appear in the April-May issue of *Strain Gage Readings* which considers all the above phenomena and many more, and which is entitled "How to Select a Strain Gage—there are 400 types on the market by eight manufacturers—order out of chaos."

MR. CLARENCE J. NEWTON (*author*).—Mr. Stein's summary of the specialized literature is to be complimented. It is gratifying to learn that improved gages and cements are constantly being developed. With regard to the inquiry on hysteresis in addition to zero-shift, I have not made a study of that phenomenon.

MR. TAAVI KAUPS[5] (*by letter*).—Mr. Newton is to be commended for bringing to the attention of the experimental analysts the phenomenon of negative permanent strains at stresses below the yield of steel.

Whether this phenomenon, which has been observed in type A-3 strain gages on annealed 1020 steel and cartridge brass specimens, also exists in other types of resistance wire strain gages on other materials has to be determined from further studies. It is recognized that it is highly critical in measurements determining the elastic limit. On the other hand, the maximum negative permanent strain of about 30 microinches per in., as observed by the author at stress levels of 45,000 to 50,000 psi, is negligibly small in strain measurements on structures and the like. The resulting maximum error in stress, found by averaging the "loading" and "unloading" strain measurements, would be about ±500 psi, which can be considered satisfactory. Of course, it re-

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[1] Clarence J. Newton, "False Negative Permanent Strains Observed with Resistance Wire Strain Gages," ASTM BULLETIN, No. 235, Jan. 1959, p. 42 (TP 12).

[2] Stein Engineering Services, Phoenix, Ariz.; Editor, *Strain Gage Readings*.

[3] The boldface numbers in parentheses refer to the list of references appended to this discussion.

[4] Such as Duco E. I. du Pont de Nemours & Co., Inc., or the special SR-4 cement by Baldwin-Lima-Hamilton.

[5] Chicago Bridge and Iron Co., Chicago, Ill.

mains to be seen to what degree other types of SR-4 gages exhibit false negative strains.

The author states that the effect of indicator drift was eliminated by taking two sets of readings, one with the active and compensating gages in the normal position, the other with the two gages interchanged. It should be emphasized that this method compensates only for the drift originating at the instrument. Any drift due to temperature differences between the active and compensating gage or humidity or other effects anywhere in the circuits would go uncompensated.

Although the author mentions that the gages were cured for a minimum of three days, he does not say what type of moistureproofing was used. Also, it would be interesting to know what method was used to assure uniform temperatures of the test specimen and compensating gage. However, the permanent strains appear to be too systematic to be blamed on uncompensated thermal strains.

A mere guess can be offered in attempting to explain the phenomenon. Assume a large shunt resistance (gage-to-shell resistance) as being in parallel with the active gage. A pull on the specimen would distort the gage and the layer of cement and presumably reduce the thickness of the insulating layer between the gage wire and shell at some point. Further, it must be argued that at some load the insulating layer fails to return to its original thickness, and the resulting shunt resistance drop would be observed as a compressive residual strain. The opposite could be applied to compressive loads. At or close to the yield point, this mechanism would lose its significance. This, of course, is a series of assumptions and would have to be verified by experimental observations.

MR. NEWTON (*author's closure*).—In reply to Mr. Kaups, each test was performed under laboratory conditions of reasonable constancy during a time interval of a few hours. Although the gages were not moistureproofed and although the effects of possible changing temperature gradients were not completely ruled out, I believe that errors from those sources under existing conditions were quite negligible with regard to the over-all behavior reported.

REFERENCES

(1) Peter Stein, "Strain Gage Adhesives: Part III—Cellulose Nitrate Cements," *Strain Gage Readings*, Vol. I, No. 2 (1958).

(2) Peter Stein, "Strain Gage Adhesives: Part IV—Epoxy Resins," *Strain Gage Readings*, Vol. I, No. 3 (1958).

(3) Peter Stein, "Contact Cement: Eastman 910," *Strain Gage Readings*, Vol. I, No. 3 (1958).

(4) Peter Stein, "Stresses Within the Adhesive Layer of Strain Gage Installations," *Strain Gage Readings*, Vol. I, No. 3 (1958).

(5) Peter Stein, "Constantan as a Strain Sensitive Material," *Strain Gage Readings*, Vol. I, No. 1 (1958).

Technical Note

A Servomechanism for Vacuum and Controlled-Environment Fatigue Testing

THIS NOTE describes a servomechanism control system used with the fatigue tester described in a recent paper[1] by the authors. The servomechanism serves three purposes: (1) to hold amplitude of vibration constant, (2) to maintain a constant center of vibration throughout a given test, and (3) to provide a simple means of stopping the test, replacing the thyratron circuit described in the original paper.

Figure 1 is a schematic diagram of the servomechanism control system. The signal from a low-frequency function generator is fed into two power amplifiers which energize two electromagnets used to vibrate the specimen. With each electromagnet and its power amplifier is associated a servomechanism. As the specimen is cycled, it alternately strikes two pairs of contacts at the two extremes of its travel. A voltage proportional to the time of contact is integrated and compared to a reference voltage. A signal which represents the algebraic difference between these voltages is amplified in the servo amplifier and causes the servo motor, through a mechanical linkage to a ten-turn pot, to change the input to the power amplifier. Since the driver magnets are oriented so that they repel the specimen magnet, the right contact controls the left electromagnet and the left contact controls the right electromagnet. By this means both the amplitude and center of vibration are kept essentially constant. In a recent 90-hr test on type 316 stainless steel, the amplitude was held constant to within 0.2 per cent.

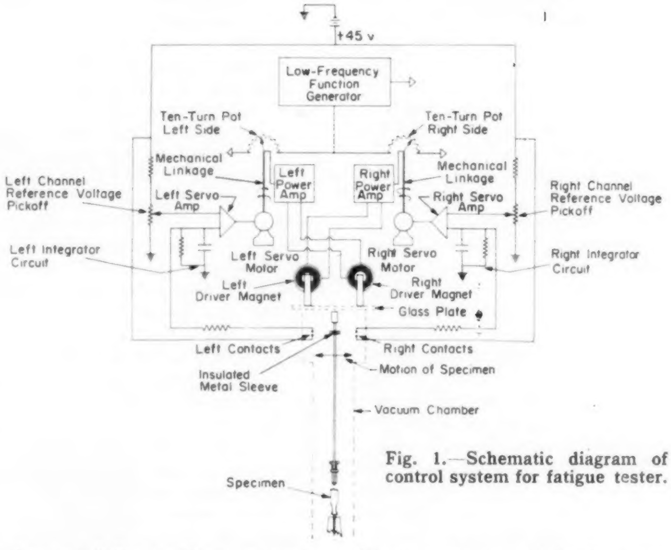

Fig. 1.—Schematic diagram of control system for fatigue tester.

The test is begun with the signal generator turned slightly below the resonant frequency of the specimen. When a crack begins to propagate, the servos drive upscale to satisfy the increasing power requirement, close a limit switch and stop the test.

Acknowledgment:

The electronic circuits were designed and constructed by the Electronics Model Shop, U. S. Naval Research Laboratory under the supervision of D. T. Phillips and S. F. Anderson.

G. J. DANEK, JR. and M. R. ACHTER
U. S. Naval Research Laboratory

[1] G. J. Danek, Jr. and M. R. Achter, "A High-Temperature, Vacuum, and Controlled-Environment Fatigue Tester," ASTM BULLETIN No. 234, Dec. 1958, p. 48.

Bookshelf

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Statistics of Extremes

E. J. Gumbel; Columbia University Press, New York (1958); 375 pp.; $15.00.

Statistics of Extremes is the second publication by Professor Gumbel which attempts to give a unified presentation of extreme value theory and application. It is a scholarly and authoritative treatise by one of the foremost authorities and contributors in this area of statistical methodology.

Since the application of extreme value theory to engineering problems is relatively new, it may be worth while to give a very brief outline of the type of problem with which it is concerned. Suppose that m samples of n observations each are presented for analysis. Thus there may be data on total rainfall of each day ($n = 365$) for a 20 yr period ($m = 20$). Analysis of data for the largest value of rainfall for each year leads to a prediction of the probability that the largest value of rainfall for some future year will exceed a stated value or a prediction as to the number of years expected before a largest value of given magnitude will recur. Only the 20 yearly largest values are used, the remainder of the data is ignored. The power of the analysis method rests upon the existence of three asymptotic distributions. Thus knowledge of the distribution of daily rainfall is not necessary since one of the three asymptotic distributions will describe the distribution of the yearly largest value if the initial distribution is one of many different types. Furthermore, graphic methods are presented from which one may determine which (if any) of the asymptotic distributions adequately represents the data. The value of such methods is obvious in instances where the only data available is the extreme (such as in breaking strength tests) and where the underlying distribution is not known. It is perhaps surprising to find that even when these situations do not obtain, analysis of extremes may yield more efficient estimates than use of all of the data. The same type of analysis can be performed for smallest values as is performed for largest values. Thus the statistical theory associated with the breaking strength of materials is one involving the distribution of the smallest values (the smallest force being required to fracture a material having largest flaws).

Since literature on the theory and application of extreme values is quite large and has appeared in many scattered journals, the extensive bibliography given in this text is most welcome. Of interest to readers of this journal are over 30 references on such subjects as: life testing, fatigue of metals, tensile strength, strength of bundles of thread, brittle strength of steel, the fracture problem, dielectric strength of paper capacitors, strength of portland cement, and structural failure. The remainder of the several hundred references (22 pages of small print are required to list them) relate to the statistical theory and to applications in such fields as prediction of floods, meteorology, aeronautics, civil engineering, geology, and astronomy.

As was mentioned above, this is the second widely circulated attempt by Professor Gumbel to present a unified treatment of extreme value theory and application. The first was "Statistical Theory of Extreme Values and Some Practical Applications" published by the National Bureau of Standards as Applied Mathematics Series No. 33, dated Feb. 12, 1954. In the opinion of this reviewer, the Bureau of Standards publication will more nearly fill the needs of readers of the BULLETIN than does the book being reviewed. At least, it would be well for one interested in learning about this subject to read first the Bureau of Standards publication. This opinion is based upon the level of knowledge of statistical methodology which is assumed by the present book. Training in the mathematical theory of statistics at the level of the professional statistician is needed. The author's review of some of the nee d statistical theory (in 13 pages of chapter 1) is hardly adequate to make up for a deficiency in such knowledge where it exists and is not needed by readers having the knowledge required to read the remainder of the book. These comments are intended as a warning to the uninitiated and are in no way meant to detract from the excellent service which Professor Gumbel has done the professional statistician in writing this book.

PHILIP BROWN

Statistical Quality Control

Schindowski and Schürz; VEB Verlag Technik, Berlin, Germany (1959); 343 pp.; approximately $3.50. (In German).

A MATHEMATICIAN and an engineer, both members of the Research Institute for Mathematics at the German Academy of Sciences in Berlin, prepared this publication for production engineers, foremen, inspectors, and setup men concerned with the continuous quality improvement of their product. In this task, the methods of statistical quality control represent efficient, modern tools which—in many production plants—are still not sufficiently well known in their various possibilities of application. One of the important uses of statistics is to indicate existence and location of error sources. Removal of the error depends on knowledge, skill, and cooperation of the worker familiar with the production process in question.

Addressing the production man rather than the scientist, this book presents the mathematical fundamentals of quality control statistics in more detail than most publications on the same subject. Yet, form of presentation and practical examples, introduced to explain the application of statistics, make this field accessible even to the reader with only modest mathematical background. Of the two basic types of statistical quality control—control of the finished product by spot checking and control of the running production process through charts—the book covers only the latter type in its various possible modifications. The subject matter is clearly grouped in chapters on statistical fundamentals, measurable and nonmeasurable quality characteristics, and statistical evaluation. The appended control chart samples, easily adaptable to any specific production process by modifying the general terminology of column and line headings in the chart's schematic, make this book a real bargain value, for those who read German, especially in view of the favorable foreign exchange rate.

The authors do not neglect to call attention to certain dangers involved in the use of statistical quality control. In the production plant, control charts should be introduced by experimentation on a small scale, granting the personnel time to gain confidence and to establish routines. Another requirement is the selection of appropriate production items and processes for this experimentation to avoid wrong conclusions on the adequacy of the statistical method applied. Success or failure in the attempt to gain the all-important cooperation of the personnel may well depend on this point.

G. G. DOCHNAHL.

(*Continued on page 86*)

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ALSO NEW: Kodak Linagraph 44 Paper, for any application of paper-eating oscillographs where extra blackness and contrast of the line are worth accepting one-fourth the speed of Linagraph 77 Paper.

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Technologically the problem reduces to the spreading of a superior light-sensitive emulsion in a superior manner on a superior paper stock thin enough to take longer recordings between reloadings and strong enough to stand stabilization processing. This widely used and rapid but rigorous machine method we had the honor to invent.

Anyone practicing paper oscillography would be cheating himself not to seize the opportunity afforded him (as a judge in the contest) to improve the appearance, readability, and reliability of the records he turns out. Either the Kodak dealer who regularly serves him or Photo Recording Methods Division, Eastman Kodak Company, Rochester 4, N. Y., can furnish all pertinent details about Kodak Linagraph 77 *and* 44 Papers.

Sorting out the vapors

Though these lines were written on a chilly evening in April, they are very likely being read when it's too hot for tedious ruminations on gas chromatography. All we want to do is hop on the bandwagon. Many a laboratory which had no gas chromatograph in April had one by July.

Should we be dismayed that 30¢-a-quart motor oil on ground firebrick can exhibit a differential in delay time for the components of a vapor mixture? That corn flakes or one of the popular four-letter household detergents can work? Can any serious gas chromatographer, mindful of the need for breadth of choice in stationary-phase liquids to fit instantly the largest variety of chromatographic occasions, doubt the wisdom of at once ordering

929 Benzyl Ether
3035 2-(Benzyloxy)ethanol
4738 Bis(2-ethoxyethyl) Ether
P4739 Bis[2-(2-methoxyethoxy)-ethyl] Ether
P6447 Di-n-decyl Phthalate
1968 N,N-Diethylformamide
5870 N,N-Dimethylformamide
2627 n-Propyl Sulfone
7311 Squalane
5404 Tetra-iso-butylene
P4770 Tri-iso-butylene
T4420 Tritolyl Phosphate . . . ?

He can, but he shouldn't. A purchase order for $34.30 would fetch him the whole group, including enough of even the more expensive ones to treat a column of packing.

Have it made out to Distillation Products Industries, Rochester 3, N. Y. (Division of Eastman Kodak Company). Whoever wants to fuss around looking up individual items among more than 3700 Eastman Organic Chemicals should write to the same address for List No. 41.

Prices stated are subject to change without notice.

This is another advertisement where Eastman Kodak Company probes at random for mutual interests and occasionally a little revenue from those whose work has something to do with science

Kodak
TRADE MARK

FOR FURTHER INFORMATION CIRCLE 239 ON READER SERVICE CARD

Bookshelf

(*Continued from page 81*)

Modern Foundry Practice

Edited by E. D. Howard; Philosophical Library, Inc., 15 E. 40th St., New York 16, N. Y., (1959); 464 pp.; Illus.; $15.00.

THIS MOST interesting and excellently illustrated book should be on the "must" list for every foundryman and foundry metallurgist. The book is admittedly a guide to British foundry practice, but American practice is so similar that little is lost. References to British molding sands, and sources of British alloys are of little use, but basic details are excellently presented in an easily readable manner.

In this reviewer's opinion, the chapters on Pattern Equipment, Moulds and Mould-Making, Cores and Core-Making, Moulding Machines and Modern Moulding Developments are of particular merit. Some phases of foundry practice such as Inspection of Castings, Foundry Work Training and Metallurgy are treated so superficially that one almost wonders why they are included.

This book, coupled with *Principles of Metal Casting* by Heine and Rosenthal, makes a valuable contribution to the training of students who wish to obtain an insight into the foundry industry.

SIDNEY LOW

Surface Defects in Ingots and Their Products, 2nd Edition

Iron and Steel Institute Special Report No. 63; The British Iron and Steel Research Assn., Ingot Surface Defects Subcommittee (Steelmaking Div.); 4 Grosvenor Gardens, London, S.W.1, England (1958); 62 pp.; Illus.; $3.50.

DURING AN investigation into the causes of ingot surface defects and their influence on the product, the Ingot Surface Defects Subcommittee of the British Iron and Steel Research Assn. became aware that there was a lack of uniformity in the names applied to the defects under review. To reduce the confusion of terms and to promote a better understanding of the nature and causes of such defects, the subcommittee selected those most commonly encountered and assigned to them the most apt term.

The first edition of this survey appeared in 1951 as No. 44 in The Iron and Steel Institute's Special Report Series, and was quickly sold out. In view of the many requests for copies of what is now a standard work of reference, it was decided to issue a second edition, with some important additional material. Through the courtesy of Richard Thomas and Baldwins Ltd., the Steel Company of Wales Ltd., and John Summers and Sons Ltd., the subcommittee has been abie to include an addendum devoted to surface defects in steel strip products.

Progress in Semiconductors, Vol. 3

A. F. Gibson, P. Aigrain, and R. E. Burgess; John Wiley & Sons, Inc.; 210 pp.; $8.50.

THE THIRD EDITION of *Progress in Semiconductors* treats seven subjects. The chapter by J. M. Wilson on the "Chemical Purification of Germanium and Silicon" covers the subject matter in some detail from a chemical viewpoint and with a considerable number of references to the work of others. The remaining chapters are more concerned with a variety of semiconductor properties of germanium, silicon, and silver halides and cadmium sulfide. A chapter by Mason and Taylor on "Silicon Junction Diodes" discusses the theoretical behavior of junctions as well as techniques for producing the junctions; the chapter concludes with construction procedures as well as a short treatment of the use of such diodes. Chapters on "Magnetoresistivity of Germanium and Silicon" by Glicksman, and "Lifetime of Excess Carriers in Semiconductors" by Many and Bray, as well as a chapter on "Scattering and Drift Mobility of Carriers in Germanium" by Sodha, discuss the theoretical concepts with some experimental evidence.

The chapter by Lambe and Klick on "Electronic Processes in Cadmium Sulfide" is in the nature of a review article. The chapter on "Electronic Conductivity of Silver Halide Crystals" by Mitchell serves the same purpose for these materials.

While this volume appears to be designed as a progress report on research in this field, it is probably better characterized as a review of information available on the various semiconductor topics, more useful to those engaged in applied rather than fundamental research.

F. J. BIONDI

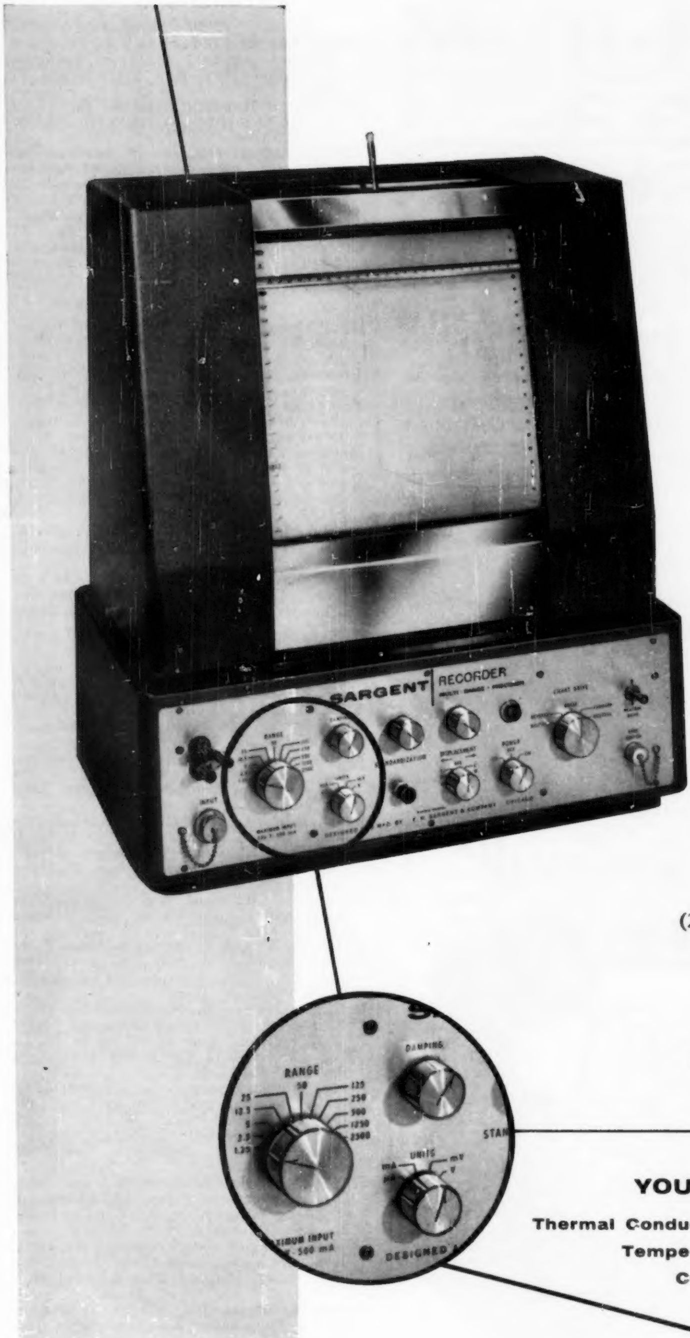
Testing of Glass Volumetric Apparatus

J. C. Hughes; National Bureau of Standards Circular 602; Superintendent of Documents, U. S. Government Printing Office; 14 pp.; 20 cents.

IN ORDER TO encourage high quality in the manufacture and accuracy in the use of precision glass apparatus for measuring volume, the National Bureau of Standards has formulated the specifications contained in this publication. Methods of calibrating and using such equipment are described, as well as the tests performed by the Bureau and procedures for submitting instruments for test. The information applies to burets, pipets, and other precision apparatus.

The Bureau admits for test only apparatus conforming to the standards listed in this circular, since apparatus of lower quality is not sufficiently precise to justify the labor required for its accurate calibration. Therefore users of such apparatus who wish to avail themselves of the Bureau's services should insist on conformity with the standard specification.

(*Continued on page 91*)


SARGENT
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UNITS

NEW MEMBERS . . .

The following 152 members were elected from April 10 to June 8, 1959, making the total membership 9856 . . . Welcome to ASTM

Note: Names are arranged alphabetically—Company members first then individuals—Your ASTM Year Book shows the areas covered by the respective Districts

Central New York District

Everts, William James, design standards engineer, General Electric Co., Utica, N. Y. For mail: 250 Hillcrest Manor Court, Utica, N. Y.

Gutekunst, Allen A., finishing supervisor, Smith-Corona-Marchant, Inc., 701 E. Washington St., Syracuse 1, N. Y.

Chicago District

Nibco, Inc., Lee Martin, president, 500 Simpson St., Elkhart, Ind. [S] †

Atherton, S. E., vice-president, Forestaire Products Co., Inc., Couderay, Wis.

Brunauer, Stephen, manager, Basic Research Section, Portland Cement Assn., Research and Development Laboratory, 5420 Old Orchard Rd., Skokie, Ill.

Flood, Walter H., owner, The Flood Co., 2157 E. 90th St., Chicago 17, Ill.

Forrester, Edward J., president, Forestaire Products Co., Inc., Couderay, Wis.

Fuller, J. P., professional engineer, Sherman Smith and Associates, 921 Summer St., Burlington, Iowa.

Hagberg, T. W., sales service manager, 211 N. Grant St., Westmont, Ill.

Hipp, J. C., chemical engineer, Centralab, 900 E. Keefe Ave., Milwaukee 1, Wis.

Krol, Adam T., president, Clearing Chemical Laboratories, Inc., 4730 W. Rice St., Chicago 51, Ill. For mail: 820 N. Maplewood Ave., Chicago 22, Ill.

Lucas, Joseph N., manufacturer's representative, AA Wire Products Co., Chicago, Ill. and Upco Co., Cleveland, Ohio. For mail: 7106 Magoun Ave., Hammond, Ind.

Maus, Roland G., vice-president, Ceresit Waterproofing Corp., Chicago, Ill. For mail: 210 Green Bay Rd., Highland Park, Ill.

Morse, W. E., Jr., city engineer, City of Waterloo, City Hall, Waterloo, Iowa.

Renwick, Frank E., Chicago Gravel Co., 343 S. Dearborn St., Chicago 4, Ill.

Russell, G. M., chief engineer, Penn Controls, Inc., Goshen, Ind.

Schlotter, H. J., director of product development, Hoerner Boxes, Inc., Main Street Rd., Keokuk, Iowa.

Stone, William C. county engineer, Boone County, County Court House, Boone, Iowa. For mail: Box 174, Boone, Iowa.

†[S] denotes Sustaining Member.
*[A] denotes Associate Member.

Cleveland District

Cone, Vernon C., chief chemist, Clevite Harris Products, Inc., Milan, Ohio. For mail: 164 W. Washington, R. R. 3, Norwalk, Ohio.

Day, J. W., president, B & K Instruments, Inc., 3044 W. 106th St., Cleveland 11, Ohio.

Kaminski, E. W., Jr., metallurgical engineer, Wooster Div., Borg-Warner Corp., Old Mansfield Rd., Wooster, Ohio.

Kent, Allen, associate director, Center for Documentation and Communication Research, 11201 Bellflower Rd., Cleveland 6, Ohio.

Schade, Willard F., principal engineer, Williard F. Schade and Associates, 401 Chester Twelfth Bldg., Cleveland 14, Ohio.

Detroit District

Detrex Chemical Industries, Inc., Thomas J. Kearney, assistant manager, Industrial Equipment Div., Box 501, Detroit 32, Mich.

Mechanical Handling Systems, Inc., L. J. Bishop, vice-president, 4600 Nancy, Detroit 12, Mich.

Colton, Arthur, engineering standards administrator, American Society of Tool Engineers, 10700 Puritan Ave., Detroit 38, Mich.

Richards, Eugene E., engineering standards supervisor, Clark Equipment Co., 741 Bedford Rd., Route 6, Box 757, Battle Creek, Mich.

New England District

Apex Tire and Rubber Co., Markus Royen, research director, 505 Central Ave., Pawtucket, R. I.

Brownell, Peter, supervisor, Research Testing, Fram Corp., Providence 16, R. I.

Freedman, Herman, plant metallurgist, Raytheon Manufacturing Co., Andover, Mass. For mail: 4 Suncrest Rd., Andover, Mass.

Harland, Raymond F., general manager, Alsop Engineering Corp., Milldale, Conn.

Kofsky, Irving L., Physics Dept., Technical Operations, Inc., South Ave., Burlington, Mass.

Molony, John P., instrument and sonic engineer, Wyman-Gordon Co., 105 Madison St., Worcester 1, Mass.

Smith, Verity Carlisle, technical service director, Barnstead Still and Sterilizer Co., 2 Lanesville Terrace, Roslindale 31, Mass.

New York District

Amerlux Steel Products Corp., N. Schilling, vice-president, 100 Park Ave., New York 17, N. Y.

Dollin Corp., C. R. Muenger, plant manager, 600 S. 21st St., Irvington 11, N. J.

Adams, George L., supervisor, Standardization Laboratory, Metropolitan Life Insurance Co., 1 Madison Ave., New York 10, N. Y.

Eisen, Howard L., chemical director, Glamorene, Inc., 175 Entin Rd., Clifton, N. J.

Lee, Robert H., chief metallurgist, Arthur Tickle Engineering Works, Inc., 21 Delevan St., Brooklyn 31, N. Y.

Marantz, I. H., chief engineer, Columbia Cable and Electric Corp., 255 Chestnut St., Brooklyn 8, N. Y.

McIntoch, William J., district engineer, Portland Cement Assn., 250 Park Ave., New York 17, N. Y. For mail: 15 Dale St., White Plains, N. Y.

Morrison, William S., Jr., assistant to technical secretary, American Welding Society, 33 W. 39th St., New York City 18, N. Y. For mail: 189-14 Crocheron Ave., Apt. 104, Flushing 58, N. Y.

Pekar, Walter, supervisor of buildings, City of Passaic, Bureau of Buildings, City Hall, 101 Passaic Ave., Passaic, N. J.

Sakai, T., Chemical Dept., C. Itoh and Co. (America) Inc., 425 Park Ave., New York 22, N. Y.

Scaperoth, Daniel, executive vice-president, Depot Construction Corp., 42-15 Crescent St., Long Island City, N. Y. For mail: Box 137, Smithtown, N. Y.

Sheffler, Frank W., staff chemical engineer, Broadway Maintenance Corp., Veon Div., 22-09 Bridge Plaza, N., Long Island City 1, N. Y.

Shimp, Hayes G., Jr., treasurer, Curry & Paxton, Inc., 866 Willis Ave., Albertson, L. I., N. Y.

Siegfried, Robert L., quality control manager, Garrett Corp., Air Cruiser Div., Box 180, Belmar, N. J.

Stewart, Isaac, consulting engineer, 21 Porter Rd., West Orange, N. J.

Strier, Murray P., chief chemist, Fulton-Irgon Corp., Box 591, Dover, N. J. For mail: Sayre Court-2A, Madison, N. J.

Turer, Jack, technical director of textile chemicals, L. Sonneborn Sons, Inc., 311 Fourth Ave., New York, N. Y. For mail: Hancox Ave., Belleville, N. J.

U. S. Corps of Engineers, Department of the Army, Eastern Ocean District, J. Benardo, librarian, 346 Broadway, New York 13, N. Y.

(Continued on next page)

New Members

Vacca, Frank J., president, Vacca Testing and Research Laboratory, 131 Highview Ave., East Chester, N. Y.

Northern California District

Bayliss, Peter, director of laboratories, Dumont Corp., 607 Irwin St., San Rafael, Calif.

Pirtz, David, associate professor of civil engineering, University of California, Berkeley 4, Calif. For mail: 252 Columbia Ave., Berkeley 8, Calif.

Sorensen, William R., 11 Montrose Ave., Daly City, Calif.

Ohio Valley District

Ramiah, B. K., soil engineer, American Testing and Engineering Corp., 5204 E. 25th St., Indianapolis, Ind. For mail: 1623 N. Delaware St., Indianapolis, Ind.

Skilken, B. Lee, vice-president, Morris Skilken and Co., Inc., 696 E. Broad St., Columbus 15, Ohio.

Thomasson, Raymond F., senior technician, Santa Fe Railroad, 3611 W. 38th St., Chicago, Ill. For mail: 211 Wyoming St., Charleston 2, W. Va.

Tyler, Leon M., Sr., technical director, Howard Paper Mills, Inc., Aetna Paper Co. Div., 116 Columbia St., Dayton, Ohio. For mail: 1652 Philadelphia Dr., Dayton 6, Ohio.

Philadelphia District

Waxed Paper Inst., Inc., 38 S. Dearborn St., Chicago 3, Ill., Paul K. Wolper, Riegel Paper Corp., Milford Mill, Milford, N. J.

Campagnoli, Louis, consultant, United Clay Mines, Inc., Trenton, N. J.

Field, Joseph, assistant metallurgical engineer, Bethlehem Steel Co., Inc., Bethlehem, Pa.

Fineberg, Herbert, director of research, Glyco Chemical Div., E. Huishing and Co., Inc., Trenton Ave., Williamsport, Pa. For mail: Box 330, Williamsport, Pa.

Jonas, Ernest A., assistant metallurgical engineer, Bethlehem Steel Co., 701 E. Third St., Bethlehem, Pa. [A] *

Raffensperger, H. P., assistant metallurgical engineer, Bethlehem Steel Co., Inc., Bethlehem, Pa.

Sahlin, Edward T., mechanical engineer, E. I. du Pont de Nemours & Co., Inc., 101 Beech St., Wilmington, Del. For mail: 1302 Kynlyn Dr., Wilmington 3, Del. [A]

Schreckendgust, Jay G., research physicist, physical testing, E. I. du Pont de Nemours & Co., Inc., 3500 Grays Ferry Ave., Philadelphia 46, Pa.

Sherwood, Henry M., manager, Magnaflux Corp., 188 W. Wingohocking St., Philadelphia 10, Pa.

Tatman, D. Russell, teaching assistant, University of Delaware, Newark, Del. For mail: 107 Martin Lane, Monroe Park, Wilmington 6, Del. [A]

Pittsburgh District

Bituminous Coal Research, Inc., Richard A. Glenn, supervising chemist, 121 Meyran Ave., Pittsburgh 13, Pa.

Beiler, A. Clarke, manager, Magnetic Engineering Dept., Westinghouse Electric Corp., Materials Engineering Dept., K-90, East Pittsburgh, Pa.

Fletcher, C. T., research metallurgist, Braeburn Alloy Steel Corp., Braeburn, Pa.

Forscher, Frederick, vice-president, Nuclear Materials and Equipment Corp., Apollo, Pa.

Holt, Marshall, assistant chief, Mechanical Testing Div., Alcoa Research Laboratories, Box 772, New Kensington, Pa.

Jensen, Claude H., electrical engineer, Copperweld Steel Co., Glassport, Pa.

Krebs, William S., metallurgist, Wheeling Steel Corp., Wheeling Steel Corp. Bldg., Wheeling, W. Va.

Nichols, H. J., research engineer, welding, U. S. Steel Corp., Applied Research Laboratory, Monroeville, Pa.

Sharp, I. W., works metallurgist, Walworth Co., Greensburg Works, Huff Ave., S. Greensburg, Pa.

(Continued on page 90)

New Members

(*Continued from page 89*)

Rocky Mountain District

Autolene Lubricants Co., Lucas Wilson, president, 1331 W. Evans Ave., Denver 9, Colo.
Denver, City and County of, Board of Water Commissioners, Mark E. Barber, field engineer, 144 W. Colfax, Denver 2, Colo.
Harness, C. E., city engineer, City and County of Denver, 376 City and County Bldg., Denver 2, Colo.

St. Louis District

Bell, Mildred L., home economics teacher, Harding College, Box 1214, Searcy, Ark.
Fischer, John, Jr., civil engineer, 348 N. Forsythe, University City 24, Mo. [A]
Foster, Verne Hollis, quality control supervisor, The Eagle-Picher Co., Box 290, Joplin, Mo.
John Brown University Library, Fred Olmey, professor of engineering, Siloam Springs, Ark.
Missouri School of Mines and Metallurgy, Department of Civil Engineering, E. W. Carlton, chairman, Civil Engineering Dept., Rolla, Mo.
Penney, W. M., superintendent of transmission and distribution, Union Electric Co., 315 N. Twelfth Blvd., St. Louis 1, Mo.
Poertner, Herbert G., public works director, St. Louis County Department of Public Works, Courthouse, Clayton 5, Mo.
Schleifer, Nicholas L., technical director, Falstaff Brewing Corp., 5050 Oakland Ave, St. Louis 10, Mo.

Southeast District

Southern Clay Pipe Inst., Inc., Lewis A. Young, secretary-manager, Suite 403-406, 1401 Peachtree St, N. E., Atlanta 9, Ga.
Foster, Charles R., coordinator of research, National Bituminous Concrete Assn., 1145 19th St., N. W., Suite 218, Washington 6, D. C. For mail: 311 First National Bank Bldg., Vicksburg, Miss.
Gomon, William Rawle, architect, Box 1671, Daytona Beach, Fla.
Hickman, Winford B., chief research and development engineer, Dorsey Trailers, 401 Hickman Ave., Elba, Ala.
Johnson, George A. Z., Jr., professional engineer, Johnson, Johnson, Johnson, Engineers, 12 Montagu St., Charleston, S. C.
MacConochie, Ian O., assistant professor of mechanical engineering, University of South Carolina, Columbia 1, S. C.
Richards, David T., mining engineer, 3623 Ibis Dr., Orlando, Fla.
Strange, E. Elston, chief analytical chemist, Heavy Minerals Co., Chattanooga, Tenn.
Watson, William A., partner, Pullara, Bowen & Watson, 2910 Grand Central, Tampa 9, Fla.
Yohalem, Ma. in J., secretary-treasurer, Smith & Yohalem, Inc., 15 N. E. Second St., Fort Lauderdale, Fla.

Southern California District

Pacific Materials Laboratory, Inc., Harold E. Babcock, president, 387 S. Arrowhead Ave., San Bernardino, Calif.
Benton, W. S., vice-president, C. H. Benton, Inc., 2136 Kettner Blvd., San Diego 12, Calif.
Corlew, Ralph P., manager of refineries, Richfield Oil Corp., 555 S. Flower St., Los Angeles 17, Calif. For mail: Box 787, Wilmington, Calif.
Dresselhaus, Donald F., owner, Dresselhaus Engineers, 528 S. Hill St., Oceanside, Calif.
Gaskell, E. G., plant manager, Ace Foundry, Ltd., 8240 Marbrisa Ave., Huntington Park, Calif.
Peterson, Elmer A., vice-president and general manager, Rocklite Products, Box 1372, Ventura, Calif.
Spencer, Russel W., senior structures engineer, North American Auia-Missile Div., 12214 Lakewood Blvd., Downey, Calif. For mail: 9660 El Braso Dr., Whittier, Calif.

Southwestern District

Cooper, Fred E., chief engineer, The Parkersburg Rig and Reel Co., Division of Parkersburg Aetna Corp., Box 13295, Houston 19, Tex.
Greer, W. H., vice-president, Southwestern Laboratories, Box 175, Houston 1, Tex.
Lawyer, James D., chemical engineer, U. S. Department of the Air Force, Tinker Air Force Base, Oklahoma City, Okla. For mail: R.R. 1, Box 14K, Choctaw, Okla.
Texas Western College, Engineering Dept., H. C. Vanzant, assistant professor, El Paso, Tex.

Washington (D. C.) District

Bell, Joseph E., testing engineer, National Crushed Stone Assn., Inc., 1415 Elliot Pl., N. W., Washington 7, D. C.
Friedrich, Eugene W., aeronautical research engineer, National Aeronautics and Space Administration, Langley Research Center, Langley Field, Va. For mail: 520 S. England St., Williamsburg, Va. [A]

Western New York-Ontario District

Aber, Jesse E., Jr., town engineer, Town of West Seneca, Engineering Dept., South Ave., West Seneca 24, N. Y.
Cox, Gilbert L., technical manager, Whitehead Metals, Inc., 181 Winton Rd., N., Rochester 10, N. Y.
Vaughn, C. E., manager of laboratories, Ritter Co., Inc., 400 West Ave., Rochester 3, N. Y.

Outside Established Districts

Columbia Hardbord Co., D. L. Johnson, sales manager, Box 1874, Seattle 11, Wash.
Anderson, Robert G., chief metallurgist, Hyster Co., Box 4318, Portland 8, Ore.
Fujita, Robert K., chief chemist, Honolulu Gas Co. Ltd., Box 3379, Honolulu 1, Hawaii.
Johnston, David A., architect, Johnston-Campanella and Associates, Box 600, Renton, Wash.
Klemgard, E. N., head, Chemical Engineering Research Section, Washington State University, Pullman, Wash. For mail: Sky-Top, Rt. 2, Box 65, Pullman, Wash.

(*Continued on next page*)

New Members

Konzen, Allan S., consulting engineer, Wisbeck & Konzen, 809 Tower Bldg., Seattle 1, Wash.

Seattle University Library, V. M. Conway, librarian, 900 Broadway, Seattle 22, Wash.

Vaughn, Tolerton H., owner, Hawaii Testing Laboratory, 2777 Mokumoa St., Honolulu, Hawaii. For mail: 3566 Puuku Ma Kai Dr., Honolulu 17, Hawaii.

Weber, N. F., plant engineer, Central Farmers Fertilizer Co., Drawer H., Montpelier, Idaho.

Other Than U. S. Possessions

Centre de Recherches, Cie Generale d'Electricite, M. Jacques Riffard, engineer, 2 rue de l'Ingenieur R. Keller, Paris 15e, France.

Ciment Quebec, Inc., Nicholas Argendeli, chief chemist, St. Basile de Portneuf, P. Q., Canada.

Ciments Portland Artificiels Belges d'Harmignies, rue du Midi 18, Brussels, Belgium.

Continental Surveyor Co., Ltd., J. H. Tsay, general manager, No. 64 1-Section Kaifeng St., Taipei, Taiwai, China.

Baschieri, Luigi, director, Istituto Costruzioni Stradali e Ferroviarie, Facolta d'Ingegneria, Universita Posa, Via Diotisalvi 1, Pisa, Italy.

Bennett, George Clarence, chief inspector, N. Hingley and Sons, Ltd., Netherton Iron Works, Dudley, Worcs., England.

Bertomeu, F., director-tecnico, Industria de Refrigeracao "Consul," S. A., Caixa Postal 267, Joinville, Sta. Catarina, Brazil.

Berwanger, Carl, lecturer, Civil Engineering Dept., University of Manitoba, Fort Garry, Man., Canada. For mail: 150 Montrose St., Winnipeg 9, Man., Canada.

Chubb, S. E., development manager, Bakelite, Ltd., Redfern Road Works, Tyseley, Birmingham 11, England.

Coal Tar Research Assn., D. McNeil, director, Oxford Rd., Gomersal, Leeds, England.

Friend, P. D., librarian, United Kingdom Atomic Energy Authority, Atomic Weapons Research Establishment, Main Library, Bldg. F6-2, Aldermaston, Berkshire, England.

Geen, Samuel B., senior evaluation engineer, Industry and Transportation Div., International Cooperation Administration, U. S. Operations Mission to Pakistan. For mail: (USOM/PAR/K) American Embassy, APO 271, New York, N. Y.

Gerry, William G., manager, Terra Engineering Laboratories, Ltd., 536 Broughton St., Victoria, B. C., Canada.

Hsu, Hwa-Chung, overseer, South Sea Textile Manufacturing Co., Ltd., 9½ Miles, Castle Peak Rd., Tsun Wan, N. T., Kowloon, Hong Kong. For mail: 201 Sai Yeung Choi St., Ground Fl., Kowloon, Hong Kong, British Colony. [A]

Josefsson, Erik Anders Ake, director of research, Stora Kopparbergs Bergslags AB, Research Dept., Domnarvet, Sweden.

Martinello, S., Ignacio, laboratory operator, Parque Resid. San Bernardino, Aptc. 24-A, Av. Fco. Javier Ustariz, Caracas, Venezuela. [A]

McAlister, William A., vice-president, Thomas J. Davis Associates, 3960th Installation Sq., APO 334, San Francisco, Calif.

McKinnon, Archibald Teale, manager, Standard Portland Cement Co., Ltd., Carbon, N. S. W., Australia.

Newfoundland Department of Highways, Soils Laboratory, 278 LeMarchant Rd., St. John's, Newfoundland.

Promislow, Albert L., research chemist, Canadian Industries, Ltd., Textile Fibre Div., Technicial Dept., Postal Bag 2800, Kingston, Ont., Canada.

Samson, Georges E., head of testing group, Anglo Paper Products, Ltd., Box 1456, Quebec, P. Q., Canada.

Schols, R. S., production chemist, Production Laboratory, Compania Shell de Venezuela, Ltd., Apartado 19, Maracaibo, Venezuela.

Soifer, John R., president, Alberta Polytubes, Ltd., 10641 102nd St., Edmonton, Alta., Canada. For mail: 10848 148th St., Edmonton, Alta., Canada.

Swedish Cement and Concrete Inst., Royal Institute of Technology, G. Wastlund, professor, Stockholm 70, Sweden.

Tremblay, Bertin, quality control engineer, Chatelaine Hosiery, Ltd., 150 Frontenac St., St. Johns, P. Q., Canada. [A]

Trupin, P. M., manager, Ready Mixed Concrete (W.A.), Pty, Ltd., Box 1, Rivervale, Western Australia.

Varden, D. P., manager, Donald Inspection Ltd., 1189 Guy St., Montreal, P. Q., Canada.

Bookshelf

(*Continued from page 86*)

Military Handbook on Lumber and Allied Products MIL-HDBK-7

U. S. Government Printing Office, Washington, D. C. (1958); 233 pp.; $1.50.

THIS HIGHLY informative handbook on lumber and allied products was developed by the U. S. Forest Products Laboratory in cooperation with the Corps of Engineers for the use of the military services for reference purposes in purchase specifications or other contractual documents.

Information contained in the handbook is of value to construction engineers, inspectors, shop foreman, receiving clerks, stock and supply clerks, and others whose duty involves the handling and use of these materials. Typical chapters deal with such subjects as What Wood Is; Lumber Grades and Sizes; Strength of Wood; Wood Preservation; Seasoning, Handling and Storage of Wood Products; Maintenance and Repair of Building; Boxes and Crates; and Receiving and Inspection.

Materials Engineering Design for High Temperatures

Joseph Marin, editor, Dept. of Engineering Mechanics and General Extension Services, The Pennsylvania State University, University Park, Pa. (1958); 420 pp.; Illus.; 8½ x 11; $9.50.

THE NINE PAPERS comprising this volume were presented in a specially planned short course, which presented to designers and research engineers the more recent developments in the behavior of materials at elevated temperatures and showed how available information can be applied to design of various high-temperature applications. Subjects covered are creep of metals; deformation properties; low-temperature brittle fracture; conventional, resonance, and acoustic fatigue at elevated temperatures; thermal stress and thermal-stress fatigue; application of material properties in mechanical design; creep design and nuclear reactor applications; aircraft structures; and creep design applications to gas turbines.

The book is photo-offset from typed manuscript and heavily illustrated with charts, graphs, and photographs. Most chapters have a substantial list of references appended.

(*Continued on page 98*)

NEWS OF MEMBERS . . .

News items concerning the activities of our members will be welcomed for inclusion in this column.

ASTM members among the newly elected officers of the American Ceramic Society are: **George Spencer-Strong,** Pemco Corp., Baltimore, Md., president; **J. J. Canfield,** Armco Steel Corp., Middletown, Ohio, and **John H. Koenig,** School of Ceramics, Rutgers University, New Brunswick, N. J., vice-presidents. **R. S. Bradley,** A. P. Green Fire Brick Co., Mexico, Mo., is past-president.

H. A. Anderson, Western Electric Co., Inc., Hawthorne Works, Chicago, Ill., retired June 9, 1959. Active in ASTM technical committee work for many years, Mr. Anderson represented Western Electric on Committees D-2 on Petroleum Products and Lubricants, D-9 on Electrical Insulating Materials, D-20 on Plastics, and D-6 on Paper and Paper Products.

Edgar C. Bain, 513 Maple Lane, Edgeworth, Sewickley, Pa., received the Ambrose Monell Medal "for distinguished achievement in mineral technology" from Columbia University. Prior to his retirement, Dr. Bain was assistant executive vice-president, operations, in charge of the Research and Technology Division, U. S. Steel Corp.

Richard E. Barnes, formerly plant engineer, Western Electric Co., Inc., New York, N. Y., is now technical director, Perlite Inst., New York, N. Y.

Donald M. Bigge, formerly metallurgist, Chrysler Corp., Detroit, Mich., is now managing engineer, Chemical Engineering Laboratories.

Charles A. Blank has joined Melpar, Inc., Falls Church, Va., as staff physicist, Chemistry Dept. Previously he was staff chemist, International Business Machines Corp., Owego, N. Y.

Homer T. Borton, chief structural engineer, The Osborn Engineering Co., Cleveland, Ohio, has been elected president of the Ohio Society of Professional Engineers.

Kristian H. Brandt, previously senior design engineer, Convair, Division of General Dynamics Corp., Pomona, Calif., is now section chief, SMSA, White Sands Missile Range, N. Mex.

Donald V. Brown has been appointed manager, sales development, Silicone Products Dept., General Electric Co., Waterford, N. Y.

Patrick E. Cavanagh is now vice-president, Premium Iron Ores, Ltd., West, Montreal, Canada. Previously he was director, Ontario Research Foundation, Toronto, Ont., Canada.

R. G. Chollar, vice-president, research and development, at National Cash Register Co., Dayton, Ohio, has been elected vice-president of the Industrial Research Inst.

W. C. Clark recently retired as consultant to the director, Design and Construction Div., Public Buildings Service, General Services Administration, Washington, D. C. Mr. Clark was very active in the work of ASTM technical committee C-18 on Natural Building Stones, having been chairman from 1940 to 1946. He also participated in the work of Committees C-20 on Acoustical Materials and E-5 on Fire Tests of Materials and Construction.

Eugene W. Cornwell, advisory engineer, Film Div., American Viscose Corp., Fredericksburg, Va., retired February 27, 1959. Mr. Cornwell was active in many ASTM technical committees, having served for 20 years on Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys and E-4 on Metallography.

Arthur Davidian, formerly director of laboratories, Wamsutta Mills, New Bedford, Mass., is now director of consumer evaluation laboratory, Lyman Printing and Finishing Co., Inc., Lyman S. C.

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News of Members

Paul L. DeVerter retired in June, 1959, from the Humble Oil and Refining Co., Baytown, Tex. Mr. DeVerter has been very active in the work of Committee D-2 on Petroleum Products and Lubricants, representing his company on that committee for many years. In addition, he served on the Administrative Committee on District Activities for five years. Mr. DeVerter plans to continue his interest in the Society through individual membership, and also to remain on the council of the Southwest District where he served as chairman from 1955 to 1958.

D. I. Dilworth, Jr., has resigned his position as director of metallurgy, Crucible Steel Company of America, Pittsburgh, Pa. Mr. Dilworth represented his company in Society membership, and also on ASTM Committee A-1 on Steel and A-10 on Iron-Chromium, Iron-Chromium-Nickel, and Related Alloys.

H. W. Field, box 5, Glen Mills, Pa., has retired as vice-president and general manager, Research and Development Dept., The Atlantic Refining Co., Philadelphia, Pa. Mr. Field joined the Society in 1951 and plans to continue his membership.

William Floyd-Jones is succeeding **Robert Gale** as secretary and treasurer of the Association of Edison Illuminating Companies, New York, N. Y.

Alexander Foster, Jr., vice-president, Warner Co., Philadelphia, Pa., had been awarded honorary life membership on the Board of Direction of the National Ready Mixed Concrete Assn. He received a plaque at the organization's February convention in New Orleans.

George F. Geiger, development and research, The International Nickel Co., Inc., New York, N. Y., retired the end of May. For many years Mr. Geiger served on ASTM Committees A-10 on Shipping Containers and B-4 on Metallic Materials for Electrical Heating, Electrical Resistance, and Electrical Contacts.

Louis E. Georgevits is now head of Casein Section, Borden Chemical Co., Bainbridge, N. Y.

Nelson Getchell has been named manager, Technical Section, Utilization Research Div., National Cotton Council, Washington, D. C.

Nelson J. Gothard, a member of ASTM since 1930, retired May 31, 1959. He was chief chemist of the Sinclair Refining Co., Harvey, Ill. Over the years, Mr. Gothard has been very active in ASTM technical committee activities, having served on Committees D-2 on Petroleum Products and Lubricants, D-19 on Industrial Water, D-15 on Engine Antifreezes, D-21 on Wax Polishes and Related Material, D-4 on Road and Paving Materials, D-8 on Bituminous Materials for Roofing, Waterproofing, and Related Uses.

Sidney H. Greenfield is now research associate, Asphalt Roofing Industry Bureau, Washington, D. C. Previously he was research engineer, California Research Corp., Richmond, Calif.

David M. Greer, consulting soils and foundation engineer, and president of Greer Engineering Associates, Inc., of Montclair, N. J., announces the merger of his business with that of Woodward, Clyde, Sherard and Associates. Mr. Greer will continue in charge of the Montclair office, which will operate under the name of Greer Engineering Associates, Inc., a division of Woodward, Clyde, Sherard, and Associates.

Victor E. Grotlisch, chief, Naval Stores Branch, Tobacco Div., Agricultural Marketing Service, U. S. Dept. of Agriculture, Washington, D. C., retired after 44½ years of service. Mr. Grotlisch, a member of the Society since 1931, has been very active in the work of Committee D-17 on Naval Stores, having been chairman from 1942 to 1958. He has also participated in the activities of Committees D-1 on Paint, Varnish, Lacquer and Related Products, E-1 on Methods of Testing, E-5 on Fire Tests of Materials and Construction, and E-8 on Nomenclature and Definitions. In June, 1959, Mr. Grotlisch received the ASTM Award of Merit.

Childress B. Gwyn, Jr. is now special projects engineer, Gibson Electric Co., Delmont, Pa. Formerly he was technical

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News of Members

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adviser, Engineering and Sales Dept., Metals and Controls Corp., Attleboro, Mass.

Weston C. Harmon, quality control supervisor, Kelsey-Hayes Co., New Jersey Div., Clark, N. J., is now test engineer, North American Aviation, Inc., Los Angeles, Calif.

Robert H. Heyer, supervising metallurgist, Research Laboratory, Armco Steel Corp., Middletown, Ohio, received a plaque awarded by the Columbus Chapter of the American Society for Metals to commemorate the first Oscar E. Harder Memorial Lecture. Mr Heyer presented a talk on "Low-Carbon Steel Sheets—Mechanical and Crystallographic Properties."

Jean E. Hittle, previously with the Rieth-Riley Construction Co., Inc., South Bend, Ind., is now professor of highway engineering, Purdue University, Lafayette, Ind.

Giles E. Hopkins, director of information, Man Made Fiber Producers Assn., 350 Fifth Ave., New York, N. Y., will become associated with American Conditioning House as consultant.

E. Konrad Kahl, formerly process and materials engineer, Raytheon Manufacturing Co., Maynard, Mass., is now consultant engineer for Konrad Kahl and Associates, Chadds Ford, Pa., Milwaukee, Wis., and Cleveland, Ohio.

Allan H. Kidder, research engineer, Philadelphia Electric Co., Philadelphia, Pa., has been elected president of the Engineering Center of the Delaware Valley.

Edward J. Kilcawley, professor and head of the Division of Soil Mechanics and Sanitary Engineering, Rensselaer Polytechnic Inst. Troy, N. Y. has been appointed to the New York State Air Pollution Control Board by Governor Rockefeller. Professor Kilcawley is chairman of ASTM Committee D-18 on Soils for Engineering Purposes.

Augustus B. Kinzel, vice-president, research, Union Carbide Corp., New York, N. Y. received the Stevens Powder Metallurgy Medal for his contribution to the advancement of the field of powder metals. This medal is given by the Stevens Institute of Technology.

Joseph F. Knasiewicz, formerly quality control engineer, Ford Motor Co., Aircraft Engine Div., Chicago, Ill., is now quality control engineer, Aerojet-General Corp., Sacramento, Calif.

Paul K. Kuhne has been appointed associate director of research, Gulf Research and Development Co., Harmanville, Pa. He was formerly director, Refinery Technology Laboratory.

Robert M. Lace, formerly technical director, Michigan Chrome and Chemical Co., Detroit, Mich., is now in advance engineering, General Electric Co., Appliance Park, Louisville, Ky.

Frank L. LaQue, vice-president, Development and Research Div. The International Nickel Company, Inc., New York, N. Y., has been appointed by the National Academy of Sciences as a representative of the American Chemical Society to the Advisory Panel of the Metallurgy Division of the National Bureau of Standards. Mr. LaQue is President of ASTM.

E. E. Laughlin, former manager for Armstrong Tire and Rubber Co., Natchez, Miss., is now technical assistant to staff management, Bendix Aviation Corp., Kansas City, Mo.

Robert John Liggett, formerly chemical engineer, Tiona Petroleum Co., Phila., Pa., is now refinery representative, Elk Refining Co., Charleston, W. Va.

Dr. Paul H. Lindenmeyer, research chemist, Visking Co., Chicago, Ill., is now manager of pioneering research.

Seymour Livis, previously engineer, Canadair, Ltd., Montreal, P. Q., Canada, is now technical engineer, Courtaulds Moulded Products, Cornwall, Ont., Canada.

William A. Mader has been named vice-president, technical services, Oberdorfer Foundries, Inc., Syracuse, N. Y. Formerly he was chief metallurgist.

(*Continued on next page*)

News of Members

G. W. Madore now chief engineer, Canadian Wanson Combustion Equipment, Ltd., Westmount, Montreal, P. Q., Canada. Formerly he was manager of engineering, Foresteel Products, Ltd., Montreal.

John P. Magos, director of research, Crane Co., Chicago, Ill., has been appointed director of engineering.

Robert G. Matters was named to head Allis-Chalmers Mfg. Co.'s new Materials Engineering Section, Steam Turbine Dept., Milwaukee, Wis.

Gordon Meldrum has been appointed assistant chief metallurgist of Republic Steel Corp.'s Central Alloy District, Massillon, Ohio.

L. F. Mulqueen, Veterans Administration, Washington, D. C., retired recently. He represented the Administation on Committee C-20 on Acoustical Materials since 1949.

R. W. Owens, formerly city engineer for the City of San Francisco, Calif., is now director of Public Works.

G. W. Paulin, chief metallurgist, Allegheny Ludlum Steel Corp., West Leechburg Div., Leechburg, Pa., retired recently. Mr. Paulin joined ASTM in 1948, and had served on Committee A-1 on Steel.

Charles U. Pierson, Jr., previously technical director, Southern Cement Co., Birmingham, Ala., is now technical director, Marquette Cement Manufacturing Co., Chicago, Ill.

John C. Redmond, former vice president, metallurgical research and development, Kennametal Inc., Latrobe, Pa., has joined Firth Sterling, Inc., Pittsburgh, Pa.

Horace A. Reeves, Jr. is now project engineer, Atlantic Prestressed Concrete Co., Trenton N. J. Formerly he was general manager, Horace A. Reeves Construction Co., Inc., Swarthmore, Pa.

Frank W. Reinhart, chief, Plastics Section, National Bureau of Standards, has been elected a Distinguished Member of the Society of Plastics Engineers in recognition of his professional eminence in the field of plastics. Dr. Reinhart is extremely active in ASTM, particularly on Committee D-20 on Plastics, and is currently serving as chairman of that committee.

Chester J. Richards, formerly metallurgist, The Clinton Machine Co., Maquoketa, Iowa, is now vice-president, Ductile Iron Foundry of Rock Island, Inc., Rock Island, Ill.

Arthur Rimmer is now physicist, Products Application Laboratory, Pilkington Bros. Ltd., St. Helens, Lancashire, England. Previously he was head, Physical Test Laboratory, Ashdowns, Ltd., St. Helens, Lancashire, England.

Stuart T. Ross is now section manager, Aeronutronic Systems, Inc., subsidiary of Ford Motor Co., Newport Beach,

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News of Members

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Calif. Formerly he was research metallurgist, Chrysler Corp., Detroit, Mich.

Libbey-Owens-Ford Glass Company has announced that **Dr. Joseph D. Ryan** has been named general director of research and development, and **Dr. Roy W. Wampler** has been appointed director of research to continue until a replacement is named. Dr. Wampler had requested retirement effective January 1, 1960.

Lawrence H. Seabright, formerly metallurgical engineer, Acme Steel Co., Chicago, Ill., has joined Amphenol Electronics Corp., Chicago, Ill., as engineering project manager.

Sherwood B. Seeley, formerly technical director, Joseph Dixon Crucible Co., Jersey City, N. J., has been named vice-president, research.

Walter P. Sinclair, supervisory materials engineer at the U. S. Naval Experiment Station, Annapolis, Md., retired from federal service on March 31, 1959, after more than 41 years at the Station. Mr. Sinclair served on ASTM technical committees C-16 on Thermal Insulating Materials, D-11 on Rubber and Rubber-Like Materials, and E-1 on Methods of Testing.

Joseph R. Stevens has been elected president of J. T. Baker Chemical Co., Phillipsburg, N. J. Formerly he was director of organic research.

Dr. John D. Sullivan, technical director, Battelle Memorial Institute, Columbus, Ohio, was recently honored by the American Ceramic Society through lifetime honorary membership. He has been extremely active in ACS, and has been one of the strong workers in ASTM Committee C-8 on Refractories, having served as chairman from 1936 to 1948. Dr. Sullivan received the ASTM Award of Merit in 1952. A vignette of Dr. Sullivan appears in the *Battelle Technical Review* of May, 1959.

Edward Bruce Tilley is now with Pacific Alloy Engineering Corp., El Cajon, Calif., as chief metallurgist. Formerly he was process engineer, Convair-Astronautics, a division of General Dynamics Corp., San Diego, Calif.

John G. Turk, formerly director, Glass Container Mfg. Inst., New York, N. Y., is now technical director, Owens-Illinois, Paper Products Div., Toledo, Ohio.

Melville W. Uffner is now chief chemist, Perlfoam, Houston, Tex. Previously he was chief chemist, Thompson, Weinman and Co., Montclair, N. J.

E. T. Walton has been appointed director of metallurgy, Crucible Steel Company of America, Pittsburgh, Pa.

Robert Edward Weigle, formerly research associate, Rensselaer Polytechnic Inst., Troy, N. Y., is now associated with Watervliet Arsenal, Research Branch, Watervliet, N. Y., as director of research.

John W. Welty, previously resident chief metallurgist, Solar Aircraft Co., San Diego, Calif., is now assistant director of research, applied research activities.

A. R. Wreath, supervisor, quality control, Victor Chemical Works, Chicago Heights, Ill., has been elected a director of the Chicago Section of the American Chemical Society for a two-year term.

DEATHS

O. T. Allen, chief, Civil Engineering Branch, Tennessee Valley Authority, Chattanooga, Tenn. (recently). Mr. Allen represented the Authority on Committee B-1 on Wires for Electrical Conductors and on a subcommittee of Committee A-1 on Steel.

W. E. Robbins, chief chemist, Caribbean Refining Co., Bayamon, Puerto Rico (December, 1958). Mr. Robbins represented his company membership in the Society.

Earl C. Sutherland, senior highway engineer, Physical Research Branch, Bureau of Public Roads, U. S. Dept. of Commerce, Washington, D. C. (April 20, 1959). Mr. Sutherland had been a member of the Society for almost 20 years.

Samuel Zerfoss, National Bureau of Standards, Washington, D. C. (recently). Dr. Zerfoss represented the Bureau on ASTM Committee C-8 on Refractories since 1955.

Bookshelf

(Continued from page 91)

The Metallurgy of Vanadium

William Rostocker; John Wiley & Sons, Inc.; 1958; 185 pp.; $8.50.

A wealth of detailed information, much of it critically reviewed and all clearly set forth, is contained in this small volume. Separate chapters are devoted to extraction of the metal from its ores and compounds and the technology of the metal, including melting, casting, forging, extrusion, machining, and other common processing operations. The constitution of those alloy systems that have been partially or totally established and the physical and mechanical properties of the metal and its alloys are covered in considerable detail. Included also is a chapter on oxidation of the pure and alloyed metal along with the problem of the attack of its oxides on other metals. One chapter deals with corrosion and embrittlement, another with metallography, and a closing chapter is devoted to the more widely known use of vanadium as an alloying agent, not only in steels but in titanium and in complex alloys.

Dr. Rostocker is most completely at home in the field to which he has contributed so much important data from his own researches and those of his associates, namely, the pure metal and its alloys, and their manipulation, their properties, and their potential uses.

Elsewhere, this reviewer must be somewhat critical, for there are "sins of omission" resulting either from failure of the author to extend his search back far enough in time or from failure of his informants to impart all that should have been presented. Thus, in considering the attack of vanadium pentoxide (V_2O_5) on metals, first observed in the early days of the mercury boiler, the importance of the presence of sulfur compounds should have been covered as well as the fact that an early, if not the first, suggestion of combating this difficulty may be found in a discussion in the ASTM *Proceedings* (Chapter 7, Ref. 5).

Many patents are referred to, but the patent search has been inadequate. In the treatment of the extractive metallurgy of the metal it is unfortunate that there is no reference to the Jenness patents on separation by sulfur chlorides volatilizing at temperatures well below those of the simple chlorides, to the Robertson *et al* patent on the quenching of the calcium vanadates, to Dunn, *et al*, precipitation of hydrated V_2O_5 instead of sodium hexavanadate, all of which have had extensive commercial use or are closer to economical application than some recent developments that are discussed in detail.

Other absences have been noted along with some minor inconsistencies, but such may be found in any volume in a technological field. The book will serve to bring many up to date on an area of metallurgy not heretofore available while its critical approach and search for explanation of observed phenomena will be of value to other researchers.

JEROME STRAUSS

Elements of Water Supply and Waste-Water Disposal

Gordon M. Fair and John C. Geyer; John Wiley and Sons, Inc. (1958); 615 pp.; $8.95.

Water Supply and Waste-Water Disposal

Gordon M. Fair and John C. Geyer; John Wiley and Sons, Inc. (1954); 1000 pp.; $16.00.

THE READER may be surprised by the double reference presented in this review. It is made to permit a comparison of two books, by the same authors, on the same subject. The reader may then select that which best suits his purpose.

"Water Supply and Waste-Water Disposal" (1954) is an important contribution to the science of sanitary engineering. It has provided the researcher and practising engineer with the best reference ever compiled on the subject. The newer "Elements of Water Supply and Waste-Water Disposal" (1958) is an easily read, simplified condensation of the original. It is intended as an undergraduate text and to this end a useful collection of 175 problems is appended. Comparison of these works shows that many of the topics originally treated separately are combined and simplified in the new book. The only complete deletion is a chapter dealing with statistical treatment of data.

"Elements" is less thorough and the subject matter is presented less intensively. This is very noticeable in the fundamental biological and chemical discussions. The undergraduate student will obtain parallel training in these areas, but the working engineer will appreciate the review and references provided by the earlier work.

The authors have combined the subjects of water supply and waste-water disposal. This is realistic since the scientific basis is the same although the art of handling the problems may differ.

"Elements" has twenty chapters. The first ten include the subjects of hydrology, collection of surface and waste water, transmission, distribution, flow, and systems design. The last ten chapters deal with treatment processes such as sedimentation, flotation, filtration, chemical and biological treatment, etc. Separate chapters on natural purification and destruction of natural growths, taste, and odors are included.

Neither book emphasizes industrial waste treatment, but the principles outlined are applicable to these specialized problems. Both contain a working diagram for solution of the Hazen-Williams formula.

In conclusion, it is this reviewer's opinion that "Elements" will be a useful undergraduate text, but the graduate student or practising engineer will prefer the earlier, more detailed book.

ROBERT A. BAKER

(Continued on next page)

Bookshelf

Introduction to Stress Analysis

Charles O. Harris; The Macmillan Co. (1959); 330 pp.; Illus.; $7.40.

THIS IS AN undergraduate textbook covering the course traditionally known as "Strength of Materials." Such a course is taught as a combination of stress analysis and strength of materials. It is not clear that a change in title is justified. Professor Harris can point out that the course contains more stress analysis than strength of materials and in this he would be right. Perhaps a correct name for the traditional university course would be "Elementary Stress Analysis and Strength of Materials," but this is too lengthy. Leaving this debatable matter, it can be said that Professor Harris' work is written with notable clarity and conciseness. Emphasis is on analysis, but such essentials as strength theories, creep, fatigue, impact, and stress concentrations are included. There is even an appendix on the resistance wire strain gage. Although the book is primarily for use in connection with the abovementioned course, it would seem that it might be of interest to some ASTM members engaged in testing who might wish to have available a compact text of recent origin as a reference.

R. E. PETERSON

National Building Code

National Board of Fire Underwriters, 85 John St., New York 38, N. Y. (1955).

OUR ATTENTION has recently been called to this code, recommended and published by the National Board of Fire Underwriters. This code has its rightful place among a small group of model building codes which are available and are sponsored by national organizations. The provisions of the code are based on minimum requirements for the proper protection of life and property from fire, including necessary provisions for public safety, health, and sanitation. It is a performance-type code which allows the use of any material, type of assembly, method of construction, or style of architecture that meets the required standards of strength, stability, and fire resistance.

It is interesting to note that a considerable number of ASTM standards are given for reference purposes in the appendix, as well as other applicable national standards.

The last full edition was in 1955, with amendments issued since that time. Copies of this code are available from the publisher, free of charge for study by local code committees or for use by others having a responsible interest. When quantities are desired, there is a nominal charge of $75.00 per 100 for the complete code, and $20.00 per 100 for the abbreviated edition. Fifty free copies of the edition will be furnished to municipalities adopting the code.

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NEWS NOTES ON
Laboratory Supplies and Testing Equipment

Note.—This information is based on literature and statements from apparatus manufacturers and laboratory supply houses. The Society is not responsible for statements advanced in this publication.

LABORATORY ITEMS

X-Ray Fluorescence—A new line of metallurgical comparison standards for rapid, highly accurate determinations of chromium, nickel, and manganese in 300 and 400 series stainless steels using conventional X-ray fluorescence techniques is now available.
Alloyd Research Corp. 3127

Thermopositor—A new instrument, the Thermopositor, collecting particles of minute size and depositing them on filter paper, electron microscope screens, and other substrates has been announced. Samples include: dust, smoke, fog, mist, bacteria, pollen, mole spores, and others, as small in size as can be seen down to the limits of resolution of the electron microscope.
American Instrument Co., Inc. 3128

Delay Lines—A new development in ultrasonic delay line design allows a 20 per cent reduction in diameter of the stock and a 40 per cent reduction in weight of the fused quartz required.
Arenberg Ultrasonic Laboratory, Inc. 3129

Portable Ohmmeter—A portable, direct-reading, precision ohmmeter providing accuracy previously available only with a resistance bridge, is now offered.
Associated Research, Inc. 3130

Temperature Regulator—New temperature regulator for proportional control of water, gas, or low-pressure steam is designed for all applications where a self-contained valve assembly may be particularly suited.
Barber-Colman Co. 3131

Ultrasonic Flaw Detector—A brand new ultrasonic test instrument, the Sonoray Model 5, has been announced. This instrument offers simplified operation, convenient size and weight for field testing, yet preserves the flexibility required for laboratory requirements.
Branson Instruments, Inc. 3132

Strain Gages—Three new, high-accuracy, MetalFilm strain gages are now available. All three gages have many, diverse applications. Some of the latest are on high-speed aircraft, missiles, and jet engines. Two of the gages are fully temperature-compensated for four alloys.
The Budd Co.
Tatnall Measuring Systems 3133

Voltage Converter—A lightweight portable instrument for converting low-voltage to high-voltage direct current has been developed.
Central Scientific Co. 3134

Impedance Plotter—The VILP (Vector Impedance Locus Plotter), a portable, laboratory instrument designed to measure continuously and plot automatically and simultaneously the rectangular components, resistance and reactance, of the equivalent series complex impedance of any passive electrical element is announced.
Chesapeake Instrument Corp. 3135

Tension Ring—The tension ring is a small and simple device for applying and maintaining a load on a tensile specimen. It is based on the principle of the elastic proving ring, which is the standardizing device used for calibrating testing machines.
Custom Scientific Instruments, Inc. 3136

Strain Gage Data Recorder—Simple, reliable, and economical method for recording in digital form the output of strain gages is provided by the new data recording system. Particularly useful where

(*Continued on next page*)

Laboratory Items

"mass production" testing of similar units must be done, the system will test structures, valves, and other metal products and give stress data in immediately usable pounds per square inch.
Datex Corp. **3137**

Recorder—For budget-conscious laboratory directors, the Recordall, a popular, all-purpose laboratory recorder is available.
Fisher Scientific Co. **3138**

Concrete Tester—The new Model QC-500 is designed specifically for testing 6 by 12 in., and 8 by 16 in., high-strength concrete cylinders; capacity 500,000 lb.
Forney's, Inc. **3139**

Power Supply—A continuously adjustable, 120-w, regulated power supply (Type 1205-B) providing uniform performance over a 0 to 300 v, d-c, output range (at 200 ma, maximum), whose over-all size is one fifth that of conventional equipment, has been announced.
General Radio Co. **3140**

Disposable Clothing—A practical, low-cost line of disposable clothing for industrial laboratory, institutional, and commercial use has been announced.
General Scientific Equipment Co. **3141**

Force Calibrator—The new Model 170 portable digital indicator and force calibrator is announced. A dual-purpose instrument, it can be used as a high-accuracy, portable, field indicator or as a calibration standard for weight, force, and thrust measuring systems.
Gilmore Industries, Inc. **3142**

Environmental Chamber—Model 8LE-CO2 is 8 cu ft, refrigerated by liquid carbon dioxide controlled by a temperature-indicating thermostat with a range of −125 to +450 F. The cabinet is heavily insulated with a combination of Kaylo high-temperature insulation and glass wool. A $^{1}/_{3}$-hp motor circulates air to assure uniform temperature throughout working chamber.
Harris Refrigeration Co. **3143**

Thermometers—An important new line of thermometers has been developed. Called "Tri-Top" thermometers, each thermometer head is made in a sharply-defined triangle shape that keeps the instrument from rolling off table tops or other surfaces.
H-B Instrument Co. **3144**

Glossmeter—A new photoelectric glossmeter has been designed for papers, paints, plastics, waxes, floor coverings, and textile yarns, fibers, and fabrics. Accuracy is assured by precise machine construction and assembly of all optical components. Adaptability of the instrument to both standard and new gloss tests is achieved by building elements of the incident and reflected light beams onto aluminum blocks which are mountable at either 75, 60, 45, or 20 deg.
Hunter Associates Laboratory, Inc. **3145**

Force Gages—Test engineers will be interested in a new line of precision mechanical force gages, capable of holding the maximum dial reading, which can be instantly reset to zero by the touch of a finger.
Hunter Spring Co. **3146**

Spectrograph—A new plane-grating spectrograph offers high optical speed and

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Laboratory Items

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good dispersion, resolution, and spectral coverage in the ultraviolet and visible regions.
Jarrell-Ash Co. **3147**

Fume Hood—The new acid-solvent storage Fume Hood is said to achieve economies in space, installation, and in operating cost, and also to offer greater safety through more efficient exhaust and the safe storing of chemical reagents at eye level. The H-400 can be centrally located in the laboratory for convenience and accessibility.
Metalab Equipment Co. **3148**

Noise Meter—A palm-size noise survey meter to monitor and measure noise hazards has been developed. Weighing only 12 oz and not much larger than an electric shaver, the instrument is housed in plastic with a leather, zippered carrying case and neck cord.
Mine Safety Appliances Co. **3149**

Thermometer—A versatile new industrial thermometer known as the Princo MultiForm, which can be turned or tilted to the most favorable reading position after the stem is in place, and which locks firmly in that position, is now available.
Precision Thermometer and Instrument Co. **3150**

Demulsibility Bath—Model D-600 demulsibility bath is an all-stainless-steel bath and well insulated to prevent heat losses. Two continuous-duty stirrers provide even distribution of heat. A Heviduty electrical heater provides long life.
Research Appliance Co. **3151**

Gas Chromatography—Entirely new modular units for gas chromatography permit close control and variable choice of conditions at each step of the process—at injection, and in separation, detection, and recording.
Research Specialties Co. **3152**

Thermocouple Wire—Revere magnesium-oxide insulated, metal sheathed thermocouple wires, designed to withstand ambient temperatures of 2000 F plus, are used where high temperatures must be measured accurately and where thermocouple leads must pass through zones of extreme heat. Constructions are manufactured in long lengths with "thermocouple accuracy" conductors of either chromel-alumel or iron-constantan.
Revere Corp. of America **3153**

Thermometer—A new line of high-temperature resistance thermometers—the MH 100, 200, and 400 Stikons—is announced. They are designed with Hytemco grids and nickel lead wires to provide high output with continuous operation to 800 F, intermittent to 1000 F.
Arthur C. Ruge Associates, Inc. **3154**

Oven—A new analytical laboratory oven designed to emphasize conduction and radiation as mode of heat transfer and to minimize the contribution of convection, thus achieving uniform temperature throughout the entire aluminum interior chamber is available.
E. H. Sargent & Co. **3155**

Fibremeter—A projection microscope for measuring the diameter of textile fibers, is designed to allow maximum ease of operation and effective protection of the most delicate parts.
Science House, Inc. **3156**

Viscometer—Automated operation of the Mooney viscometer is announced with the claim that 75 per cent of operator's time may be saved thereby. This is made possible by the fact that after the operator inserts the test specimen and sets the controls, the machine takes over and completes the viscosity test automatically.
Scott Testers, Inc. **3157**

Galvanometer—A fast-reading, percent-limit bridge that measures resistance values up to six significant figures with an accuracy of ±0.2 per cent is available. Known as Model 617-07, the new instrument is designed for either rack- or bench-mounting in laboratory, inspection, and production departments.
Shallcross Mfg. Co. **3158**

Miniature Strain Gage—An improved, airborne, strain-gage-signal amplifier system is announced. Model CA9 is designed to save space and weight while reducing system complexity. Operating from 28 v dc (nominal) input, and supplying internal regulation, the single package combines both the power source for excitation and the signal amplifier, with self-contained balance and gain controls, delivering 0 to 5 v dc output.
Statham Instruments, Inc. **3159**

Portable Tensile Testers—A new family of portable tensile testers has been developed for making tensile tests on round or flat specimens anywhere. These testers are not dependent on outside power of any kind, since the load is applied manually by rotating a knurled knob.
Steel City Testing Machines, Inc. **3160**

Pipet Controller—Bulb-free, valve-free, completely automatic pipet controller has been introduced. The Clinac Pipetter completely eliminates the need for mouth pipetting of infectious bacteria, toxic or ill-smelling liquids, corrosive as well as radioactive material.
Tenso-Lab, Inc. **3161**

Plastic Tester—A new instrument known as the Continental Plastisol Cure Tester consists of three components: a Vicat-type penetrating needle test unit, a regulated power supply for needle motion transducer, and a millivolt strip-chart recorder for plotting penetration of the needle and elastic recovery of the material.
Thwing-Albert Instrument Co. **3162**

Mortar Grinder—With a minimum of time this electric grinder pulverizes all types of material to a fineness suitable for analytical purposes or any other particle size as desired. High-speed grinding is particularly desirable for repetitive control sampling.
The Torsion Balance Co. **3163**

Strain Gage—A new strain-gage control module, designated Model SRB-200, is available. This module combines a strain-gage power supply with the strain-gage balance and calibration circuitry.
Video Instruments Co., Inc. **3164**

Grader—The new Wheeler material grader is of special interest to materials engineers, laboratory operators, and research scientists. It is said to grade granular material to seven sizes in one operation.
Delbert Wheeler **3165**

(*Continued on page 104*)

CATALOGS & LITERATURE

Vibrator Tester—Eight models of mechanical vibrator testers are described in new *Bulletin No. 3759*.
All American Tool & Mfg. Co. **6077**

Spectrochemical Unit—A vacuum spectrometer, the Quantovac, is claimed to possess unexcelled accuracy and precision in the analysis of all types of iron alloys. Technical paper describes techniques used.
Applied Research Laboratories, Inc. **6078**

Temperature Test Chamber—A new environmental test chamber for low-high temperature testing in the range of −100 to +1000 F is available.
Associated Testing Laboratories, Inc. **6079**

Foil Gage—A new, 6-page SR-4 Foil Gage *Bulletin No. 4320* has been released. SR-4 etched foil gages with improved design and engineering features represent a forward step in the area of stress analysis.
Baldwin-Lima-Hamilton Corp. **6080**

Magnifiers—Descriptive catalog providing a simplified, accurate means of selecting magnifiers and readers has been announced. The 14-page illustrated booklet, *I-52*, lists over 65 individual models.
Bausch & Lomb Optical Co. **6081**

Condenser Microphones—Bruel & Kjaer *Technical Review* of 24 pages presenting a new condenser microphone series has been announced. Major advances in measurement microphone design are described and the exact measurement of the free field correction is discussed.
B & K Instruments, Inc. **6082**

Pressure Standard—A 4-page technical brochure describes and illustrates a portable, electronic, secondary-pressure standard incorporating direct conversion of input pressures to a digital FM signal for rapid, accurate, line, bench, and process pressure checks.
Borg-Warner Corp. **6083**

Chromatography—A new 52-page *Catalog No. 84* lists and describes more than 134 instruments and accessories available for gas and vapor chromatography. In addition, 158 different listings of partitioning agents are offered.
Burrell Corp. **6084**

Strain Gages—Availability of a 4-page *Bulletin No. 106* describing a new line of strain-gage instrumentation and input conditioning equipment is announced. It includes information on strain indicator, millivolt-per-volt standards, switching units, regulated power supplies and amplifiers for strain gage use.
Bytrex Corp. **6085**

Moisture Detector—Type 26–350 series of high-pressure moisture monitors are described in *Bulletin 1855*. Set forth in this 2-color bulletin are applications, specifications, and operating features of the two moisture monitors in this series.
Consolidated Electrodynamics Corp. **6086**

Pye Galvanometers—A new 6-page folder describes the Pye "Scalamp" Galvanometers with complete optical system and built-in Ayrton-Mather six-place shunt in a range of eight instruments.
The Ealing Corp. **6087**

Analyzer—Bulletin FS-277 describes Serfass Hydrogen Analyzer for determination of hydrogen in steel, titanium, nickel, columbium, and other metals.
Fisher Scientific Co. **6088**

Counting and Control Equipment—A complete line of reliable, high-speed, electronic counting and control equipment is featured in the illustrated *Catalog No. 5920* now available.
Freed Transformer Co. **6089**

Microscopy Catalog—A 26-page catalog describes various accessories for microscopy. New 1959 edition.
Ernest F. Fullam, Inc. **6090**

Chemicals Data—Data sheets for 13 chemicals are available in a folder form.
Golden Bear Oil Co. **6091**

Precision Standards—A catalog of precision standards of mass, volume, and length has been issued. The 32-page illustrated *Bulletin No. 1500*, will be of interest to officials responsible for standardization programs.
W. & L. E. Gurley **6092**

Inertia Switch—A totally new operating principle features the ultrareliable, highly accurate acceleration switches described in a new brochure published recently. Remarkably simple in design, these acceleration-sensitive switches have only one moving part: a precision-ground steel ball held against a solid base by a uniform magnetic field.
Inertia Switch, Inc. **6093**

(*Continued on page 106*)

Catalogs & Literature

(*Continued from page 104*)

Laboratory Clamp—A 6-page brochure illustrating and detailing the new laboratory clamp line is now available.
Labasco 6094

Film Badge—Just released is a new 8-page brochure describing radiation monitoring services. The booklet covers the complete film badge service, the different types of badges, and the evaluation and control methods used.
R. S. Landauer, Jr. & Co. 6095

Research Brochure—A 37-page brochure describing the industrial and government product research and development services is available.
Mast Development Co., Inc. 6096

Relay Tester—A 2-page catalog describing the application and operation of an automatic relay tester is offered. The instrument is designed to determine the pull-in and fall-out characteristics of relays on a production-line basis.
Mid-Eastern Electronics, Inc. 6097

Magnetic Amplifier—Descriptive literature covering the specifications, operation, and function of the new Brown magnetic amplifier is now available. Dimensions, schematic and operating diagrams, as well as ordering information are given.
Minneapolis-Honeywell Regulator Co. 6098

Radiation Measurement Systems—New 6-page *Bulletin 105-C* describes the operating principles, performance, and advantages of Ohmart gamma radiation measuring systems for density or specific gravity and liquid level control.
The Ohmart Corp. 6099

Measuring Instruments—*Bulletin E*, describing the new "Pet-line" gages and measuring instruments is now available.
Petz-Emery, Inc. 6100

Use of Radiation—A 12-page booklet on the use of X- and gamma rays for nondestructive inspection and product testing has been published.
Picker X-Ray Corp. 6101

Temperature Cabinets—A 32-page catalog describing the new constant-temperature cabinets is available. Fourteen types of cabinets including ovens, and special purpose models are listed.
Precision Scientific Co. 6102

Radiation Counting—A 4-page brochure presents theory of radioisotope measurements; highlights applications in chemical, food, paper, petroleum, plastic, and rubber industries; and describes operating characteristics and applications of RCL's nuclear thickness and density gages.
Radiation Counter Laboratories, Inc. 6103

Electrometer—Data Sheet *EIL 33/3* describing the Vibron electrometer is designed to measure very small d-c voltages and currents derived from high-impedance sources. The heart of this instrument is a vibrating capacitor which replaces the conventional input tubes of electrometer circuits.
Milton Roy Co. 6104

Glassware Catalog—"SGA" *Catalog 59* having 1568 pages, contains thousands of illustrations and numerous helpful tables and charts. An 80-page index with cross references (on colored paper) separates the general apparatus and equipment section from the SGA-fabricated "Inter-Joint" glassware section. All page headings are alphabetized, all catalog numbers are in sequence. If your laboratory does not have this new catalog, write directly to the Scientific Glass Apparatus Co., Inc., Bloomfield, New Jersey, on company letterhead.
Scientific Glass Apparatus Co., Inc. 6105

Concrete Quality Control—A 6-page folder on the three basic tests for concrete quality control is now available. The leaflet shows how the slump test, air entrainment determination, and testing of concrete cylinders is performed.
Soiltest, Inc. 6106

Quality Control—Technical purchasing executives may now obtain the new 224-page TMI catalog and register of testing machines. It comprises 87 different broad categories of physical testing areas such as abrasion testing, hardness testing, thickness testing, moisture testing, and 83 others.
Testing Machines, Inc. 6107

Gas Temperature Measurement—A technical paper on gas temperature measurement from 2500 to 3500 F delivered at the annual symposium of the New Jersey Chapter of the Instrument Society of America is available.
Thermo Electric Co., Inc. 6108

INSTRUMENT COMPANY NEWS

Wm. J. Hacker & Co., Inc., West Caldwell, N. J.—William J. Hacker & Co., Inc. was named national representative for Struers, producers of a complete line of

(*Continued on next page*)

Instrument Company News

(*Continued from page 106*)

metallographic specimen preparation instruments based on the well-known "Knuth-System" developed in Europe. This line includes several pregrinders. (wet grinders), diamond and electropolishers, specimen mount presses, automatic sample mover, and a newly developed instrument for electromechanical polishing based on the Reinacher method.

NEWS OF LABORATORIES

Harris Laboratories, Inc., Lincoln, Neb.—The acquisition of equipment and facilities of Soil Consultants Bureau, Kansas City Testing Laboratories, Kansas City, Mo., by Harris Laboratories, Inc., Lincoln, Neb., was announced. Lewis F. Harris, president of Harris Laboratories, stated that the physical equipment of the Kansas City firm was being moved to their Lexington Laboratories Division at Lexington, Neb., where it will be used to expand research and testing facilities.

York Research Corp., Stamford, Conn.—In the May issue of the BULLETIN, York Research Corp. was erroneously reported as being capable of making vibration tests at frequencies up to 300 cps. The frequency range capability is actually from 5 to 3000 cps.

Other Societies' Events

August 10–13—**Society of Automotive Engineers,** International West Coast Meeting, Hotel Georgia, Vancouver, B.C.

August 25–27—**American Institute of Electrical Engineers,** Petroleum Industry Conference, Wilton Hotel, Long Beach, Calif.

September 9–10—**American Society of Mechanical Engineers,** 2nd International Congress of Air Pollution, Statler-Hilton, New York, N. Y.

September 9–12—**Electron Microscope Society of America,** Annual Meeting, Ohio State University, Columbus, Ohio

September 10–11—**American Society of Mechanical Engineers,** Wood Industries Div., Portland, Ore.

September 10–11—**Society of the Plastics Industry,** Midwest Section Conference, French Lick-Sheraton, French Lick, Ind.

September 10–12—**American Ceramic Society,** Structural Clay Products Div., Alfred University, Alfred, N. Y.

September 13–18—**American Chemical Society,** National Meeting, Convention Hall, Atlantic City, N. J.

September 14–15—**American Ceramic Society,** Basic Science Div., Massachusetts Institute of Technology, Cambridge, Mass.

September 14–16—**American Society for Quality Control,** 14th Midwest Quality Control Conference, French Lick-Sheraton, French Lick, Ind.

September 17—**Natural Gasoline Association of America,** Rocky Mountain Regional Meeting, Wyoming-Gladstone Hotel, Casper, Wyo.

September 17–18—**ASME and AIEE,** Engineering Management Conference, Statler Hotel, Los Angeles, Calif.

September 20–22—**Steel Founders' Society of America,** Fall Meeting, The Homestead, Hot Springs, Va.

September 20–23—**American Society of Mechanical Engineers,** Petroleum Division Conference, Houston, Tex.

September 20–23—**American Public Works Assn.,** 1959 Public Works Congress and Equipment Show, Olympic Hotel and Armory, Seattle, Wash.

September 20–24—**American Transit Assn.,** Annual Meeting, Hotel Leamington, Minneapolis, Minn.

September 21–22—**Standards Engineers Society,** Annual Meeting, Hotel Somerset, Boston, Mass.

September 21-25—**Instrument Society of America,** Annual Instrument-Automation Conference and Exhibit, International Amphitheatre, Chicago, Ill.

September 22–24—**3rd Industrial Nuclear Technology Conference,** Morrison Hotel, Chicago, Ill

September 27–30—**American Institute of Chemical Engineers,** Hotel St. Paul, St Paul, Minn.

September 27–30—**National Sand and Gravel and National Ready Mixed Concrete Associations,** Semi-Annual Meeting, Lake Placid Club, Lake Placid, N. Y.

September 28–30—**American Oil Chemists' Society,** Fall Meeting and Exhibit, Hotel Statler, Los Angeles, Calif.

September 28–October 1—**Association of Iron and Steel Engineers,** Sherman Hotel, Chicago, Ill.

September 28–October 1—**American Welding Society,** Sheraton-Cadillac, Detroit, Mich.

Federal Government Standards Index Changes

The Federal Supply Service of the General Services Administration is charged with the responsibility for establishing specifications to be used by the Federal Government for procurement of materials and supplies. The GSA issues an annual Index of Initiation of Federal Specifications Projects, and monthly supplements.

The items listed below appeared in Supplements 1 and 2 for March and April 1959.

INITIATONS

(Supplement 1, March 1959)

Title	Type of Action	Symbol or Number	FSC Class	Assigned Agency & Preparing Activity
Adhesive; Asphalt, Water Emulsion Type (for Asphalt Tile)	New	SS-A-00138a (COM-NBS)	8040	COM-NBS
Baking Soda (Sodium Bicarbonate)	Rev.	EE-B-86b	6505	GSA-FSS
	New	EE-B-0086a (GSA-FSS)	6810	
Cloth, Cotton, Percale	New	CCC-C-447	8305	DOD-Army-QMC
Cloth, Cotton, Duck, Plied-Filling-Yarns and Single Yarns (Flat-Duck)	New	CCC-C-443	8305	DOD-Army-QMC
Fiber Drums	Rev.	PPP-D-723	8110	COM-BDSA
Sheathing Board, Gypsum	Am. 3	SS-S-276	5640	GSA-FSS
Tape, Friction	Rev.	HH-T-00101b (Navy-Ships)	5970	DOD-Navy-Ships
Textile Test Methods	New	Fed. Std. No. 191	8305	COM-NBS

(Supplement 2, April 1959)

Title	Type of Action	Symbol or Number	FSC Class	Assigned Agency & Preparing Activity
Calcium Hydroxide—Barium Hydroxide Mixture	Am. 1	U-C-60	6505	DOD-Navy-MMSA
Cement, Masonry	New	SS-C-00181d	5610	COM-NBS
Cements, Portland	New	SS-C-00192c	5610	COM-NBS
Cements, Portland, Blast-Furnace, Slag	Rev.	SS-C-00197a	5610	COM-NBS
Conduit, Electrical, Aluminum, Rigid	New	WW-C-00540 (GSA-FSS)	5975	GSA-FSS
Copper Alloy, Centrifugal Casting	New	—	9630	DOD-Army-Ord
Copper Alloy, Continuous Casting	New	—	9630	DOD-Army-Ord
Copper Alloy, Static Casting	New	—	9630	DOD-Army-Ord
Copper Casting Alloys (Chemical Compositions & Mechanical Properties)	New	—	9630	DOD-Army-Ord
Dishwashing Compound, Hand	New	P-D-410	7930	DOD-Army-QMC
Leather Dressing, Mildew-Preventive	Rev.	O-L-164b	8030	DOD-Army-QMC
Metals, Test Methods	Rev.	Fed. Std. No. 151	..	DOD-Army-Ord
Molding Plastic, Polystyrene	Am. 2	L-M-520	9330	DOD-Navy-Ships
Pipe Fittings, Bronze (Screwed) 125-Pound and 250-Pound	Rev.	WW-P-460	4730	DOD-USAF
Pipe Fittings (Bushings, Plugs, and Locknuts, Bronze and Ferrous (Screwed)	Rev.	WW-P-471	4730	DOD-USAF
Pipe, Steel (Seamless and Welded) (for Ordinary Use)	Rev.	WW-P-406a	4730	DOD-USAF
Sealing Compound, Two Component, Elastomeric, Polymer-Type, Jet Fuel Resistant, Cold Applied, Concrete Paving	New	SS-S-00200 (Army-CE)	8030	DOD-Army-CE
Steel Plates, Shapes and Bars, Carbon, Structural	Rev.	QQ-S-741a	9520	DOD-Army-CE
Zinc, Sheet and Strip	Am. 2	QQ-Z-301b	9535	DOD-Navy-Ships

PROMULGATIONS

(Supplement 1, March 1959)

Title	Type of Action	Symbol or Number
Calcium Chloride, Dihydrate and Calcium Chloride, Anhydrous, Technical	Am. 1	O-C-105a
Molding Plastic, Cellulose Acetate	Am. 1	L-M-505
Pigment, Chromium-Oxide-Green, Dry (Superseding TT-C-00306a(GSA-FSS and TT-C-306)	New	TT-P-347
Pigment, Copper-Phthalocyanine-Blue, Dry (Superseding TT-C-00610a(GSA-FSS) and TT-C-610)	New	TT-P-355
Pigment, Zinc-Dust (Metallic-Zinc-Powder), Dry Superseding TT-Z-00291a(GSA-FSS) and TT-Z-291)	New	TT-P-460
Sodium Phosphate, Tribasic, Technical, Anhydrous, Dodecahydrate, and Monohydrate	Am. 2	O-S-642
Wire, Copper-Nickel-Zinc Alloy	New	QQ-W-340
Wire, Steel, High Carbon, Spring, Bright, Music	Am. 2	QQ-W-470a

(Supplement 2, April 1959)

Title	Type of Action	Symbol or Number
Cleaning Compound, Synthetic Detergent, (Non-Abrasive)	New	Fed. Std. No. 126
Lubricants, Liquid Fuels, and Related Products, Methods of Testing	Chg. Not. 4	Fed. Test Method Std. 791
Soap, Grit (Hand, Paste, and Powder)	New	Fed. Std. No. 120a
Dishwashing Compound, Hand (Neutral Synthetic Detergent, Solid Form)	New	P-D-410
Glass Cleaner, Powder	Am. 2	P-G-411
Plastic Compounds, Molding, Cellulose Acetate Butyrate, and Molded or Extruded Parts	Am. 2	L-P-349a
Plywood, Container Grade (Superseding NN-P-515)	Rev.	NN-P-515a
Soap, Borax, Powder (Superseding P-S-628b)	Rev.	P-S-628c
Soap, Laundry, Chip (Superseding P-S-C0580 (GSA-FSS) and P-S-566b)	New	P-S-580a
Soap, Toilet, Hard, Soft or Sea Water	New	P-S-617
Tape, Pressure-Sensitive, Adhesive, (Cellophane and Cellulose Acetate) (Superseding L-T-0090b (GSA-FSS))	New	L-T-90c
Ties, Railroad, Wood (Cross and Switch)	Am. 3	MM-T-371b

INTERIM FEDERAL SPECIFICATIONS ISSUED

(Supplement 1, March 1959)

Title	Type of Action	Symbol or Number
Cloth, Cotton, Sheeting	Am. 1	CCC-C-430 (GSA-FSS)
Lead, Calking	New	QQ-L-00156a (Navy-Ships)
Lead, Sheet and Plate	New	QQ-L-00201b (Navy-Ships)
Sieves, Standard, for Testing Purposes	Am. 2	RR-S-366b (COM-NBS)

(Supplement 2, April 1959)

Title	Type of Action	Symbol or Number
Towels, Paper	New	Int. Fed. Std. 007a (GSA-FSS)
Acoustical Units, Prefabricated	Am.	SS-A-118b (GSA-FSS)
Leather, Rigging	Am. 1	KK-L-241b (Navy-Ships)
Steel Strapping, Flat	New	QQ-S-00781c (Navy-Ships)
Valves, Bronze, Angle, Check and Globe, 125- and 150-Pound, Screwed and Flanged (for Land Use)	New	WW-V-0051b (GSA-FSS)
Valves, Bronze, Gate, 125- and 150-Pound, Screwed and Flanged (for Land Use)	New	WW-V-0054a (GSA-FSS)

CANCELLATIONS

(Supplement 1, March 1959)

Title	Symbol or Number	Reason for Cancellation
Bone-Black, Dry (Paint-Pigment)	TT-B-600	Superseded by Fed. Spec. TT-P-330
Boxes, Paperboard, Metal Stayed (Including Stay Material)	PPP-B-665 (Am. 1)	Cancelled
Bronze, Aluminum, Plate, Rolled Bar, Sheet, and Strip	QQ-B-667	Superseded by Fed. Spec. QQ-A-620

(Supplement 2, April 1959)

Title	Symbol or Number	Reason for Cancellation
Chromium-Oxide-Green, Dry (Paint-Pigment)	TT-C-306	Superseded by Fed. Spec. TT-P-347
Copper - Phthalocyanine - Blue, Dry (Paint-Pigment)	TT-C-610	Superseded by Fed. Spec. TT-P-355
Zinc-Dust (Metallic-Zinc-Powder), Dry (Paint-Pigment)	TT-Z-291	Superseded by Fed. Spec. TT-P-460

SPECIFICATIONS AND STANDARDS APPROVED FOR PRINTING

(Supplement 2, April 1959)

Title	Type of Action	Symbol or Number
Cleaning Compound, Synthetic Detergent (Non-Abrasive)	New	Fed. Std. No. 126
Soap, Grit (Hand, Paste, and Powder)	New	Fed. Std. No. 120a
Calcium Hydroxide-Barium Hydroxide Mixture	New	U-C-60
Molding Plastic, Polystyrene	Am. 2	L-M-520

Bookshelf

(*Continued from page 99*)

Distillate Fuel Storage Stability

Summary Report No. 2; Western Petroleum Refiners Assn.; 1428 Hunt Building, Tulsa 3, Okla.; Free.

IN THE LATTER part of 1958, the Western Petroleum Refiners Assn. released *Summary Report No. 2*, "Studies Relating to Causes of Instability," as the second of a series of reports on distillate fuel storage stability. These reports are the fruits of cooperative research by the Western Petroleum Refiners Assn. and the Bureau of Mines' Petroleum Experiment Station, Bartlesville, Okla.

Summary Report No. 1, released earlier, presented stability data on distillate fuel samples representing crude oil from the major foreign and domestic producing areas, and covered straight-run, thermally-cracked, and catalytically-cracked distillates. Storage data from tests conducted with different temperatures, catalysts, container sizes, and atmospheres are included in this report.

Summary Report No. 2 attempts to define some of the factors causing instability. Some of the topics are: trace metals, their identification and possible effects; polar materials; composition of the gums, including separation into soluble and insoluble gums and elemental analyses; oxidation susceptibility of distillate fuels at several temperatures, some results in chromatographic separation and subsequent oxidation of the fractions, and data on the oxidation of pure hydrocarbons.

Both reports should be of much interest to technologists, chemists, and others who produce, sell, or consume distillate fuels and diesel fuels. It is hoped that these reports will encourage more detailed research by other investigators on problems of instability and storage of fuels.

Mechanical Properties of Metals

L. W. Hu and Joseph Marin, editors; Dept. of Engineering Mechanics and General Extension Services, The Pennsylvania State University, University Park, Pa. (1958); 296 pp; Illus.; 8½ by 11; $8.50.

THE 12 PAPERS in this volume were presented at a short course by educators and representatives of 12 universities, industrial laboratories, and instrument manufacturers. Emphasis was placed on recent developments in the field of determining the mechanical properties of metals and in interpreting the significance of the properties. Subjects discussed include elastic and plastic behavior, creep resistance, and fatigue strength, the effects of temperature, impulsive loading, and radiation, as well as the philosophy, principles, and developments of testing apparatus.

The book is photo-offset from typed manuscript and illustrated with charts, graphs, and photographs.

Installation and Maintenance of Resilient Smooth-Surface Flooring

Publication No. 597; Building Research Institute, National Academy of Sciences-National Research Council, 2101 Constitution Avenue, N. W., Washington 25, D. C.; $5.00.

A WEALTH OF information based on the experience of people connected with this subject is included in the report of a research correlation conference on installation and maintenance of resilient smooth-surface flooring conducted by the Building Research Institute, September 17 and 18, 1958, in Washington, D. C. The subject was approached from several angles, with the conference being opened by papers dealing with the BRI survey of flooring problems and the environmental factors affecting design, the latter paper being based on the experience in federal government buildings. All papers are presented in abstract form.

The conference was arranged to cover three primary areas: bases for resilient smooth-surface flooring, fastening methods for base and finish flooring, and resilient smooth-surface flooring materials and maintenance. Additional information is available in three appendices: the first, a sample of the questionnaire used in the BRI survey of flooring problems; the second, the results of the survey; and the third, selected comments from the representatives to the survey questions.

INDEX TO ADVERTISERS

OTS Research Reports

THESE REPORTS, recently made available to the public, can be obtained from the Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C. Order by number.

Design and Construction of a Gas-Liquid Partition Chromatographic Unit, and its Application to the Quantitative Analysis of Liquid Solutions, PB 151008. $1.

A Simple Bend Test to Measure Uniformity of Ductility in Sheet Metal, PB 131947. 50 cents.

Improved Metallographic Technique for Revealing Temper Brittleness Network in Ordnance Steels, PB 131941. $1.

Fracture Strengths Relative to Onset and Arrest of Crack Propagation, PB 151131. 75 cents.

The Evaluation and Adaptation of the Bromination Technique of Determining Oxygen in Metals, PB 151250. $1.

Rocket Exhaust Corrosion Simulator, PB 151273. $2.75.

Cleaning and Passivation of Corrosion-Resisting Steels, PB 131964. 75 cents.

Effect of Halide Addition to the Sulfuric Acid Pickling Bath, PB 131794. 75 cents.

Mechanism of the Oxidation of Hydrocarbons, PB 151016. $2.75.

Catalogs of Technical Reports for Uranium. Part 1, Uranium-General, CTR-365. *Part 2, Alloys and Compounds*, CTR-366. 10 cents each.

An Evaluation of Fungicidal Treatments in Cotton Cargo Parachute Webbings Stored at Wright Air Development Center, Part 1, PB 131158. $2.50.

An Evaluation of Fungicidal Treatments in Cotton Cargo Parachute Webbings Stored at College, Alaska, Part 2, PB 151252. $1.50.

Development and Evaluation of Waterproof Two-Way-Stretch Laminated Fabrics, PB 151034. 75 cents.

Evaluation of Fungicidal Vinyl Coated Cotton Duck, PB 151464. $1.50.

Investigation of Printed Circuit Methods for Relay Applications, PB 151259. $3.50.

Regulated Power Supply Analysis and Design, PB 151121. $2.50.

Topological Network Theory, PB 515416. $1.

Annual Research Task Summary, 1959 Edition, a 6-volume report, contains a brief description—purpose, scope, approach, and status as of September, 1958—for each project in the Army Research and Development Program:

Volume 1—Biological, Medical, Social and Behavioral Sciences and Operations Research, PB 151494, $3.25.

Volume 2—Chemistry, PB 151495, $2.

Volume 3—Physics, Part 1, PB 151496, $3.50.

Volume 4—Physics, Part 2, and Mathematics, PB 151497, $3.

Volume 5—Geophysical Sciences and Engineering, PB 151498, $4 75.

Volume 6—Materials Technologies, PB 151499, $2.75.

A Review of the Air Force Materials Research and Development Program: Supplement 5, PB 111648S4, $3.50.

Report of Conference on Effects of Nuclear Radiations on Materials Sponsored by Ordnance Materials Research Office, PB 151001, $2.25.

The Mechanical Properties of Certain Aircraft Structural Metals at Very Low Temperatures, PB 151459, $1.75.

An Investigation of the Relationship Between Microstructure and Creep-Rupture Properties of Heat-Resistant Alloys, PB 151421, $2.

Stress Relaxation in Structural Materials, PB 151516, $1.25.

Phase Relationships in the System Iron-Aluminum-Oxygen, PB 151000, $1.50.

Cyclic Creep Buckling of Integrally Stiffened Aluminum Alloy Panels, PB 151515, $2.75.

Low-Cycle Fatigue of Notched and Unnotched Specimens of 2024 Aluminum Alloy Under Axial Loading, PB 151355, $2.25.

Corrosion Resistance and Mechanical Properties of Aluminum Powder Products, ANL-5927, 50 cents.

The Effect of Temperature on the A-C Magnetic Properties of Nickel-Iron Alloys, PB 151601, $1.25.

The Preparation and Properties of 14 to 17-per cent Aluminum-Iron Alloys, PB 151472, $1.25.

Hydrogen Embrittlement of Plated Steel Springs, PB 151125, $1.25.

Crack Propagation Tests of Some High-Strength Sheet Steels, PB 151352, 75 cents.

The Effect of Metal Purity on Chromium-Base Alloys, PB 131999. $1.25.

Development of Active-Eutectoid Base Alloys, PB 151518, $1.50.

Development of a Heat-Treatable Titanium Sheet Alloy, PB 151279, $2.25.

Determination of Materials Design Criteria for 6Al-4V Titanium Alloy at Room and Elevated Temperatures, PB 151274, $4.

Some Factors Involved in Forging Titanium Alloys, PB 131945, $1.

Department of Defense Titanium Sheet-Rolling Program: Thermal Stability of the Titanium Sheet-Rolling-Program Alloys, PB 151061, $1.25.

High-Temperature Mechanical Properties of Tantalum, BMI-1326, $1.

Friction and Wear of Refractory Compounds, Progress Report, APEX-454, $1.50.